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SHELTER ELECTRICAL EQUIPMENT S-318()/G - FINAL REPORT

Report No. 13

Contract No. DA-36-039-SC-90814(E)

Task No. 1Eb 34301 D 24606

Period: 15 June 1962 - 30 September 1964

Submitted to: U. S. Army Electronics Laboratories
Fort Monmouth, New Jersey

From: Twin Industries Corporation
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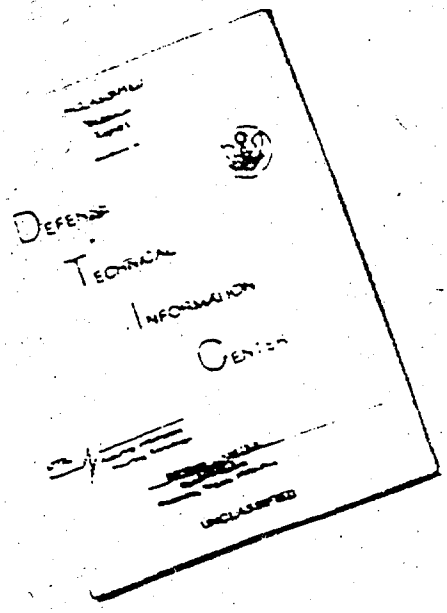

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Report No.	13
Contract No.	DA-36-039-SC-90814(E)
Technical Requirement Number and Date:	Electronics Command Technical Requirement SCL-4366C dated 4 August 1964 with Amendment No. 1 dated 4 September 1964
Task No.	1Eb 34301 D 24606
Period:	15 June 1962 - 30 September 1964
Concept:	Construction of a Thinwall Lightweight Field and Mobile Shelter, designed for transport by Truck, Cargo, 3/4 ton, 4 x 4, M-37, and by fixed or rotary wing aircraft
Prepared by:	Edmund R. Moore, Liaison Engineer

TABLE OF CONTENTS

I. PURPOSE

This report covers the design and structural requirements of a thinwall lightweight field and mobile shelter capable of transport by truck, cargo, 3/4 ton, 4 x 4, M-37, and by fixed or rotary wing aircraft.

Request for Quotation for research and development of two (2) lightweight thinwall field and mobile shelters was received by the Aerospace Division of Twin Industries Corporation, Buffalo, New York, from the Signal Corps Procurement Agency. The shelter to be designed and tested to meet the requirements of a shelter of less weight and more structural durability as a replacement for the S-153 and S-144 type shelters which were at that time operational. The nomenclature S-318()/G Shelter Electrical Equipment was assigned to the new design. The physical appearance of the S-318 is illustrated on Enclosure #I-1.

Preliminary conferences which subsequently resulted in preliminary ideas and designs were submitted to the Signal Corps for evaluation and comment. With past experience in design and development in the shelter industry, Twin Industries was able to submit a workable plan at reasonable costs. As a result, in June of 1962 Twin Industries received a purchase order for research and development of a lightweight thinwall field and mobile shelter.

A meeting of Twin Industries Engineering personnel and representatives of the Government was arranged to discuss design requirements of this shelter in detail. Comparisons were made to its counterpart, the S-153 and S-144 shelter, as an aid in accomplishing the desired end product. Accordingly, Twin engineers started preliminary designing and testing to properly evaluate and select materials that would conform to the rigid requirements of the S-318 concept. Subsequently, preliminary design engineering was concluded and released to

applicable in-plant departments for analytical review relative to required processes, methods, procurement, manufacturing and quality assurance.

The Planning Department established method procedures and manufacturing operations. Time estimates were initiated to establish schedules covering procurement, detail fabrication and assembly.

Procurement Department reviewed engineering data to confirm material requirements based on type, size and quantity. Priority rating was established on purchased items of a special nature where long lead time became apparent.

Quality Assurance was advised through the media of released engineering data of the specifications governing all phases of the project. Raw stock, purchased parts and various items requiring certification were closely inspected to insure conformance to specifications and drawings as applicable. Quality Assurance was also responsible for all phases of tests necessary to establish that all materials conformed to the requirements as set forth. Test reports were maintained for record purposes and any subsequent review necessary. All materials, purchased parts, fabricated parts or otherwise were inspected and approved prior to release to manufacturing departments. The manufacturing departments had been alerted through the media of conferences and preliminary engineering information. Materials for detail fabrication, sub-assembly and major assembly had been previously procured through similar media. Detail fabrication and assembly was controlled through process planning operations and by Quality assurance procedures.

At this point, liaison engineering was utilized to coordinate fabrication activities with engineering drawings and changes. It was the responsibility of the Engineering Department to carefully check and approve the final stages of fabrication of all parts. Drawings were kept up-to-date, whereby reflect-

ing any and all changes that were necessary to correct and attain the desired result.

With the fabrication process completed, the parts were again checked by Quality Control for conformance to drawings as well as to standard acceptable manufacturing procedures, before final assembly or installation. All parts were then installed and assembled to drawing requirements. Liaison Engineering was present to correct any area that was mis-matched or discrepant. The drawings were than up-dated before finalization for release to the Signal Corps.

With the shelter completely assembled and painted, Quality Control inspected the completed item, checking all exterior and interior dimensions for correct fit, hardware, and final weight, to insure the shelter was in conformance to the requirements set forth.

The shelter was readied for shipment to its destination by whatever mode of transportation acceptable to the Signal Corps.

Engineering prepared a running set of drawings to the Signal Corps for checking, revisions, comments, and/or acceptance. Any check prints returned for additions, deletions, etc., were forwarded to the Engineering Department. The revisions were incorporated and a final submission was made.

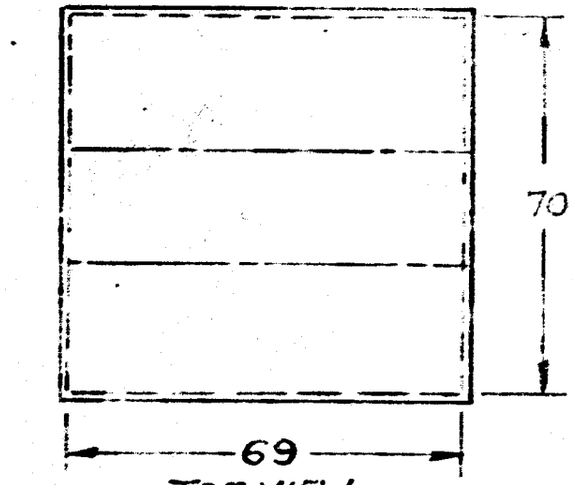
All tests were conducted by the procuring agency. The second shelter fabrication was delayed, pending the test results of the first shelter.

In January of 1963, the S-318 Shelter Program was transferred to Twin Industries Corporation, Special Products Division, Sayre, Pennsylvania. At this time a request for re-design of the second S-318 Shelter, which was classified as an Advanced Procurement Model #1, was received by the Special Products Division of Twin Industries Corporation. The Statement of Work included re-design, fabrica-

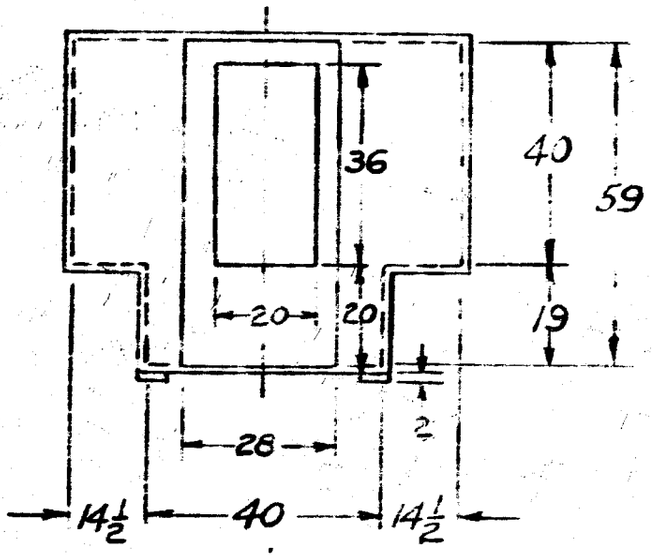
tion and tests. The same phases of operation applied to this procurement of the contract as did the first procurement, with one major exception.

Quality Control, in addition to its other responsibilities, was to initiate First Article Test Procedures to insure all requirements set forth in the applicable specifications and requirements were met. They established scheduling of many tests and test facilities, whether within the facility of Twin Industries or subcontracted to another facility capable of meeting the test requirements. The completed shelter was tested in accordance with all requirements set forth by the Signal Corps. All tests were witnessed by a Government representative and were certified as complying to the requirements set forth. Failures were rejected, the discrepancy noted, repaired/approved in preparation for a re-test.

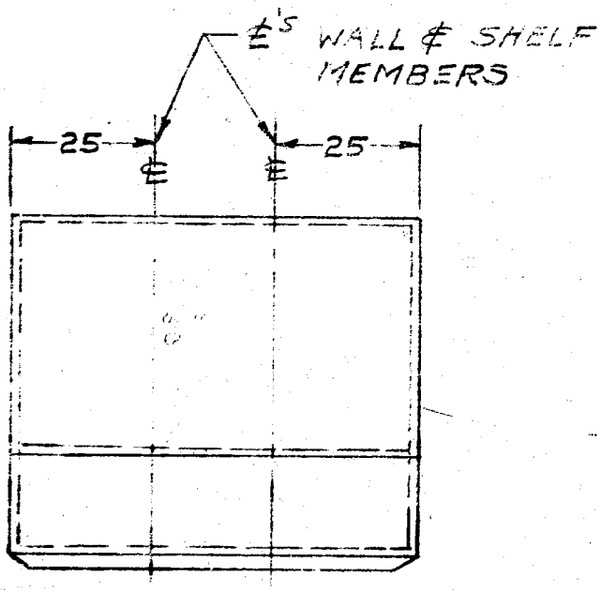
ENCL. I-1



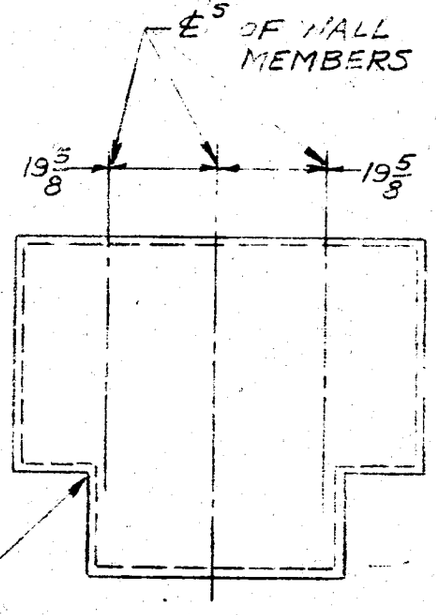
TOP VIEW



FRONT VIEW



SIDE VIEW



REAR VIEW

HORIZ. MEMBERS ADDED AT LATER DATE TYP. 4 PLACES

II. ABSTRACT

The receipt of the purchase order in June of 1962 initiated the basic design, planning, material purchase, quality control, and manufacturing of a thinwall, lightweight field and mobile shelter capable of being transported by a M-37 truck and by fixed or rotary wing aircraft.

The design and manufacture of the shelter began in June of 1962 and proceeded through its scheduled phases of construction to May of 1963. During its initial design stages, many problems arose in material selection and performance tests. Forming and spot welding of material to be used was, and still is, very critical. Holding the weight to the required 300 pounds was an impossibility due to skin splices, doubler strips, excessive adhesive, sealer, and paint, and door hardware weight increase, all of which were not anticipated at the beginning of the contract. The shock mounts design, although workable, created problems which had to be contended with. With all unforeseen problem areas, a great amount of time was consumed than originally expected. Material procurement delays added to the continual daily problems encountered. The sheet stock in particular was continually unavailable. When the shelter was completed, it was submitted to the Signal Corps for evaluation and testing. Twin Industries representatives were not present for any of the tests conducted. The tests were conducted by the Equipment Evaluation Branch of the Equipment Division in August of 1963. At the completion of the tests, it was the opinion of the testing laboratories that the shelter did not meet the requirements set forth by the Government.

The following January, 1964, an order was received for the re-design and

manufacture of the second S-318 Shelter. The shelter was re-designed using additional strength in the areas of failure resulting from the Signal Corps tests. Design changes acceptable to the Signal Corps Agency were incorporated.

At this time, Quality Control assumed responsibility for conducting and scheduling of the required tests. The S-318 Shelter, with one heavily damaged wall resulting from vehicle and railroad transportation tests, was removed from test schedule and repaired. The repair was unacceptable to the Signal Corps Agency; therefore, a new wall had to be fabricated before tests continued. The shelter again, as an original fabrication, had to be re-tested to the schedule of the Government. Upon completion and acceptance, the shelter was shipped and the drawings completed for final submission. Through design and fabrication of two (2) S-318 Shelters, changes which will improve the shelter are still being processed, tested, and investigated. Since the development stages of this new shelter to the present time, thirty (30) production units have been made, four (4) of which were modified. The end result is a shelter of a more substantial structure, meeting all the requirements of the original specification with the exception of target weight which had increased from 300 pounds to 415 pounds.

III. CONFERENCES

June 1962

Representatives of the Twin Industries Corporation and the Signal Corps Agency met at Fort Monmouth to discuss the lightweight, thinwall shelter design program. Twin Industries was informed that, as an aid in their required design, test reports for the S-153 Shelter would be furnished, which at that time was undergoing tests.

The RFI shielding problem was mentioned that, although the final tests were to be conducted at Fort Monmouth, it may be possible that preliminary tests could be performed at Twin Industries by Signal Corps personnel with no expense to Twin Industries. The Signal Corps Agency stated that all thermal barrier applications could be placed where Twin Industries decided it would be best and where it was compatible with the design. Submission of the designs and stress analysis was mentioned as items to be supplied to the Signal Corps. Mention was made that the design goal of three hundred (300) pounds be accomplished and, at the same time, be of the best possible design.

November 1962

Representatives of Twin Industries Corporation again met with representatives of the Signal Corps Agency at Fort Monmouth. Design points of the lightweight, thinwall shelter were discussed. The longitudinal members in the ceiling and floor were not what the Signal Corps expected; however, the Signal Corps stated they would investigate the situation further to establish if it would be acceptable. The Signal Corps also requested further investigation of the shock skid. They were pleased with the attenuation figures, but expressed

concern over the height. The SCL specification called for a height of 2" and our proposed skid with no load, had a 2.6" height. The reason for the critical height requirement was to insure that the shelter when mounted on an M-37 truck and loaded aboard an aircraft, the overall height requirement would not be tight. At this time, examination of the S-153 which had undergone tests was possible. It was noted by Twin Industries representative that a member in the wall had collapsed with the first test and with each succeeding test increased the amount of buckling, etc. The lifting eye, when tested, failed completely and had been pulled off the shelter. After viewing these discrepant areas on the S-153, Twin Industries was able to incorporate and increase the structure to avoid similar problems.

Normally, loose equipment and lifting slings should be considered as part of the shelter weight, but in the contract these items would not be considered part of the weight. Request was made that one lifting eye casting as used on Twin Industries S-144 Shelter be forwarded for evaluation. In regard to RFI shielding, it was suggested Twin Industries contact Emerson and Cuming in regard to Eccoshield which is a room cure sealer that has a high conductivity. The product had been investigated by the Signal Corps RF group and found to be one of the best materials available.

IV. FACTUAL DATA

PART #1

Request for Quotation for research and development of two (2) lightweight, thinwall field and mobile shelters was received from the Signal Corps Procurement Office by the Aerospace Division of Twin Industries Corporation, Buffalo, New York. As a direct result of design and cost analysis, a purchase order was received shortly thereafter.

Preliminary conferences held at Fort Monmouth, New Jersey, established in detail exactly what was to be expected from this new shelter. As an aid only, comparisons were made to the S-153 and S-144 Shelters, both of which were operational at the time. It was the intention of the Signal Corps to have developed, a S-318()/G Shelter to replace both the S-153 and S-144, both of which were larger and weighed too much for the applications desired by the Government.

The new configuration is light in weight, compact and structurally strong. Enclosure #I-1 indicates the proposed shape and size of the S-318 Shelter.

Statement of Work for the research and development of the S-318 consisted of: Services and materials for a scheduled eighteen (18) months and a design plan to conform to dimensions as indicated on Enclosure #I-1. Aluminum structural members were to be incorporated as follows:

a. At all corners
b. Adjacent to the door
c. All locations as shown on Enclosure #I-1

The shelter shall be completely of sandwich construction with aluminum skids riveted or welded to the outer faces of the structural members and riveted or

bonded to the inner faces. If rivets are employed on the inner skins, they shall be countersunk. Trim angles may be employed on interior corners, but shall be flush with the inner skins. All spaces between inner and outer surfaces of walls, roof and floor shall be filled with foam-type core material, bonded in place. There shall be a minimum number of heat conducting paths from inside the shelter to the outside. To this end, there shall be insulating strips between the inner skins and all structural members.

The roof shall be designed to support a snow load and ice load of forty (40) pounds per square foot and shall be capable of being walked on by military personnel wearing heavy field shoes. The roof shall be capable of withstanding the impact of the lifting sling dropping on it from its fully extended height. The roof shall contain one (1) spring loaded hand hold located one (1) foot from the roof edge centered on the folding steps.

The shelter shall be equipped with two (2) doors, one within the other which shall be centrally located in the rear wall. The smaller section shall be capable of being opened without dropping the tailgate of the transporting vehicle when the shelter is mounted in a Cargo Truck M 37. Both sections of the door shall open outward, and shall include provisions for holding the doors at the 100 degree position. Door latches of the dead bolt type shall be provided and both sections shall have simultaneous latching at three (3) points. The door latches shall be simple and easy to operate under all conditions, but shall prohibit accidental opening when the shelter is being transported or roughly handled in any manner. The door shall have complete gasketing adequate to meet climatic conditions and flotation requirements. Each door shall be sufficiently strong to support 150 pounds applied at the maximum distance from the hinge line. The door locks shall be contained in the door handles and shall be releasable from the inside without the use of

a key. Locks and keys shall be coded H700.

The shelter shall be quipped with four (4) lifting eyes, one at each upper corner, for hoisting the loaded shelter with cranes, for helicopter pick-up and transport, and to tie down the shelter in a M-37 Truck. The inside clearance of each lifting eye shall be three (3) inches. The lifting eyes shall not protrude on the sides or the top of the shelter. The lifting eye assembly shall be attached by bolts to permit replacement without damaging the shelter.

Two (2) skids, two (2) inches in height, shall be mounted longitudinal on the undersurface of the shelter. These skids shall permit the shelter, with a full payload, to be towed for limited distances over rough terrain. The design of the skids shall be compatible with the loading requirements of the C-119 Aircraft and M 37 Truck. These skids shall be compatible in design with the requirements for towing eyes. The skids shall exert bearing pressures no greater than 6 psi when the shelter is loaded with a 1200 pound payload and resting on a level surface. The skids shall be capable of supporting the entire weight of the loaded shelter at any point along their length when the shelter is balanced on a two-inch diameter pipe placed under the skids. The skids shall be attached to the shelter by bolts to permit replacement without damaging the shelter.

Two (2) towing eyes shall be provided on each end of the shelter. They shall be attached to the shelter itself (not to the skids) and shall be conveniently located for towing the shelter over rough terrain and for loading and unloading from a Type C-119 Aircraft and Type M 37 Truck. Inside diameter of the eyes shall be 1-1/2 inches. The towing eyes shall not protrude on the sides or bottom of the shelter. The towing eye assembly shall be attached by bolts to

permit replacement without damage to the shelter.

Two (2) recessed folding steps to provide access to the roof shall be installed at the right rear corner above the tailgate. They shall be Eberhard Part No. 1-575709 as manufactured by Eberhard Manufacturing Co., or equal. The steps shall withstand a load of 400 pounds applied to the outer section.

The wall and floor structural members shall be capable of serving as supports for the equipment installed in the shelter. Their design shall be such that 5/16 inch diameter steel rivnuts, or equal, serving as the attachment points for the equipment, can be installed in them on the inner wall and floor and such that they can withstand the dynamic loads imposed on them through the rivnuts. Their section thickness, plus heat barriers and inner skin thickness, shall be such that one grip length rivnut can be utilized throughout the shelter.

A combination lift and tie-down assembly shall be provided for lifting the shelter and for tieing it down in a M-37 Truck.

Hardware for the shelter, consisting of such items as door handles, shall be operable by personnel wearing artic-type gloves. The large mittened hand is defined as the human hand size extended 1/2 inch in all directions. All locks, latches, hinges, as well as other hardware used in the construction of the shelter, shall be treated to prevent corrosion.

The shelter shall be given a protective finish. This includes finish of hardware such as handles, hinges, screws, etc., and necessary touch-up after mounting. The final paint film on exterior surfaces and the door interior shall be semi-gloss enamel, color OD.

The interior surfaces shall be light green semi-gloss enamel, except for the floor which shall be lusterless ocean gray.

Wherever practicable, parts and assemblies shall be so mounted that identification markings will be readily visible with minimum dis-assembly of the equipment. A data plate reflecting requirements for air transportation shall be provided. The shelter shall also be provided with a nameplate. Wall floor and roof mounting members shall be properly identified with markings on the interior walls of the shelter in order to provide location information for mounting equipment.

Based on the requirements as indicated under Statement of Work, Article I, of the governing contract the following shall be submitted:

One (1) Preliminary Test Model

One (1) Engineering Test Model

One (1) Set of Preliminary Manufacturers Drawings (Non-Reproducible Type) covering Preliminary Test Model

One (1) Set of Manufacturers Drawings (Reproducible Type) covering Engineering Test Model

Monthly Reports and Final Report

Investigations and tests were proposed to establish suitable materials which would meet requirements set forth.

Sandwich panel samples were fabricated and panel bow tests were conducted using a variety of foam core and density. (See Enclosure # IV-1) Styrofoam 2-pound density was selected due to its greater compressability, load carrying advantages which is required because of thin skin material and to keep the weight to a minimum.

Sample strips of aluminum alloy were made and spotwelded together as shown on Enclosure # IV-2 . Alloy 7075-T6 Alclad was selected because of its high strength physical properties.

Extensive research had been initiated into the development of a shock skid which would meet the critical requirements set forth. These requirements are: Material which would absorb shock, have excellent load-bearing capacity, deflection, and 100% reset. Urethane elastomers were selected to meet these requirements. Size, shape and durometer had to be determined before tests could be scheduled.

A preliminary weight analysis was established. (See Enclosure # IV-3) At this time, total estimated weight was approximately 298.6 pounds; approximately 1.4 pounds under the requested 300 pounds.

A preliminary stress analysis was forwarded for evaluation and comments. (See Enclosure # IV-4) This analysis depicted specified loads on the roof, floor, end panels and special consideration to the cantilevered shelf assembly, which absorbs a great deal of the applied loads of the equipment that may be mounted on the seat.

From June until August of 1962, preliminary designs and tests were continually being advanced. On September 1, 1962, the first of a preliminary set of drawings consisting of the completed shelter assembly, details of the walls, door, and skids, was submitted by Twin Industries Corporation to the Signal Corps for review and comment. The scheduled delivery of the first unit could not be met, resulting in the Government granting an extension to January 31, 1963.

In October of 1962, the following information resulted in extensive investigation and research of a shock design:

A molded urethane elastic tube (Dunlop trade name "Duthane") enclosed in a telescoping skid channel indicated good promise for acceptable shock reduction at reasonable weight and production cost.

Lightweight shelter requirements specify two (2) skids along the 74" shelter length. Allowing 2" for ramp slope at each skid end, we arrived at an effective length of 140" of shock absorbing tube for the shelter.

The requirements further specify a shelter empty weight of 300 pounds maximum, plus a payload of 1200 pounds, totaling 1500 pounds. The result is a static load of 10.7 pounds per linear inch of shock absorbing tube.

In the skid samples made for static and dynamic tests, molded Duthane tubing, 96 durometer (Shore A), 2.5 inches outside diameter, .25" wall thickness, molded in 12" lengths, were used. This tube, when placed lengthwise in the skid, necessitates a 2.5" square cross section of the skid channel in the static load position. Sample #1 of Enclosure # IV-6 shows the tube so arranged. Static test cure, Enclosure # IV-7 shows satisfactory load and deflection values for such a skid. However, requirements specify a skid height of 2". The width of skid is not given, but scaling of Signal Corps drawing indicated a width of 3" was desired. We noted it was not advisable to place a 2.5" diameter tube in a 2 x 3 inch channel, and recommended the use of a 2.5" square skid channel or place a tube of 2" diameter across the skid channel as approximately shown in Sample #2 of Enclosure # IV-6 . Static test results, depicted in Enclosure # IV-7 , shows that for tubing of equal diameter and total length, a loss of 50% of load bearing capacity results when a tube is placed across the skid centerline. It was noted if a 2.5" skid height was not acceptable, experimentation with a 2" diameter tube placed either along the skid centerline in twin fashion or across the centerline was to be applied.

Two (2) pieces of test Sample #1 (See Enclosure # IV-6) were drop tested to determine the amount of deflection and general performance. The test result is shown on Enclosure # IV-8 . Recorded values are for the corner which indicated the most skid deflection on an average of two (2) drops per each drop height. Dis-assembly and inspection of the samples on completion of 36 drops disclosed no damage except for a slight galling of the rubbing surfaces of the aluminum channels. This condition is undesirable because it slows recovery to full skid height after impact. Teflon spraying of rubbing surfaces or formica rubbing strips will correct this condition.

To assure continued progress, the following action was required:

Procure four (4) channels of impact measuring equipment.

Obtain a full set of basic drop test data on a S-144 Shelter loaded to 1500 pounds.

Produce one (1) set of shock skids, with provision for drop test with Duthane tube in either the "in line" or "across" direction.

Repeat basic drop tests on a S-144 Shelter loaded to 1500 pounds with one (1) set of shock skids with provision for test with Duthane tube in either the "in line" or "across" direction.

Conduct tests on a 2 x 3 inch skid cross section if a 2.5 x 2.5 inch skid is not acceptable.

In December of 1962, review of Twin Industries' design was approved by the Signal Corps with exception to the longitudinal structurals which could be utilized providing additional testing could substantiate that the design would stand up under loads required by the racks in the shelter.

Skids were approved with exception to the height. 2-inch height was again stated as a rigid requirement. In addition, drain holes were to be added to relieve water that could be trapped during fording tests.

In December of 1962, procurement of materials and fabrication began. At this

time, it was obvious that the delivery date of January 31, 1963, could not be met. An extension to March 13, 1963, was requested. The request was granted on January 9, 1963.

In January of 1963, material such as extrusions and premium sheet, which have a long lead time on delivery, were not being received. In addition, a definite date of receipt could not be given.

It was noted engineering completion depends on procurement and fabrication. Without final fabrication and assembly it is impossible for Engineering to release finalized drawings as they are dependent upon conformity between the finished product and completed engineering data.

At this time, another extension was requested due to unexpected delays in raw material procurement. The request was granted by the Signal Corps, extending the date to April 12, 1963.

Prior to the above date, most delays and problems were primarily due to procurement of material. In April of 1963, difficulties in bonding were encountered, making delivery impossible. One panel which had been fabricated was unsuitable for actual use on the shelter; therefore, another had to be fabricated. The rejected panel was used for static load tests. (See Enclosure # IV-9). As this was construed as a technical difficulty, which does not warrant an extension in delivery, it was Twin Industries' responsibility to state that this type of construction was new and required complete research and development. It was not possible to accurately predict all potential problem areas. As an example, the amount of research and development work which was done on the shock skids alone was over and above contractual requirements. It was the aim of Twin Industries to construct a shelter which would favorably pass all test requirements and be acceptable to the specifica-

tions and standards of the Signal Corps Agency. To accomplish this, additional effort and expenditures by Twin Industries was to be expected. At this point, random thoughts for improvements were also being noted, which included:

Floor and Step-Wall Assembly - This part takes most of the drop test abuse. Skin and structure must match perfectly before spotwelding because load must be taken by both at the same time. Our present design (all types) calls for a brake-formed outer skin and internal structure welded at the corners. Since such details cannot be made to zero tolerances to get the perfect match necessary to take the load, the skin will wrinkle along edges and corners on impact. Production adjustment must be provided to obtain the necessary match.

Spot Welding - Sound spots of adequate diameter and proper spacing are an absolute necessity. In addition, the flatness of a thin gage skin must not be destroyed in spot welding. The spot welding on this shelter is very unsatisfactory as evidenced by the many spots which "popped" during shelter assembly and had to be repaired with rivets. This item may cause serious trouble on test. Up-dating of spotweld equipment and procedure, and stricter quality control, is necessary.

Panel Bond Assemblies - Uniform wall thickness, straightness, flatness and adhesive soundness is important on any shelter panel and most important on lightweight construction. A panel with .016 skin cannot be assembled in the same manner as one with a .040 skin. The following points should be adhered to:

a. Skins must be flat. Dents, wrinkles, bulges and oil cans must not be tolerated.

b. Internal details, such as foam core, structural members, and insulating strips, must be of matching uniform thickness.

c. Foam cores must fill their respective areas completely. If they do not, adhesive will fill the void, adding excessive weight.

d. Adhesive must be applied only to the surfaces to be bonded. Adhesive must be applied to form a film of even thickness.

e. Flat and rigid overlay plates must be used when bonding panels with skin of less than .032 thickness. Stepped structures, such as the floor and shelf assembly, require a rigid and accurate form to nest the outer skin.

f. Framed openings for doors, windows, etc. must be held to size and location with braces or plates.

g. Bonding pressure must be applied evenly over the entire area of overlay plates. If vacuum is used, it must be prevented from getting between skins and overlays.

Skin Splices - Skin splices cannot be avoided on most shelters, especially on skins which come in comparatively small sheet sizes only. A good splice must be strong, tight, light, practical to make, and neat in appearance. Spotwelded overlap, used on this job, is not adequate. The "folded seam" approach should be investigated.

Foam Core Data - Foam core data is far too meager, unreliable and spread over too many pieces of advertising literature to be of much use to the designer. The laboratory should re-test the characteristics given by foam manufacturers for some of the most common types used, and issue one composite data sheet for ready use.

Rivets - The shear strength of a riveted joint is weakened when a thin gage skin is deformed during the process of making the rivet head. This is especially true when the design calls for a rivet head to be made on the side of the thin sheet such as joining the outer skin (.016) to the endband (.125). A drill will not give a hole of satisfactory diameter and roundness in light gage sheet, necessitating the use of drill-reamer combination tools on light-weight construction. In addition, it is necessary to spotweld doubler strips along thin gage skin edges which are to be riveted.

Threaded Blind Inserts - A rivnut will provide adequate holding power and torque resistance when it is installed in solid metal in accordance with in-

stallation instructions. However, when installed in a sandwich structure, the holding power is marginal or inadequate when standard installation instructions are used insofar as drill size and grip length is concerned. A drill which produces a satisfactory hole in solid metal will produce a sloppy hole in a sandwich structure. During installation of the insert in such a hole, the rivnut will first expand to fill the hole and the remaining length will be too short to form a head of adequate diameter and flatness.

Since the severity of the above condition is in direct proportion to the softness of the plywood strip and thinness of skin, the hole size (not drill size) and grip length of a rivnut should be stated on each drawing. In drilling insert holes through sandwich structures, a combination drill-reamer tool should again be considered.

The merits of inserts other than rivnuts must continue to be investigated. Shur-Lok Fasteners Company representatives have an experimental insert (SL-81 series) with a knife thread on its outer diameter. This insert can be screwed into the undersize hole of a sandwich structure similar to a self-tapping screw. Their test report shows a pull-out power of 2600, 2700 and 2800 pounds on a typical shelter sandwich structure.

Southco Fasteners Company representatives have also submitted experimental inserts for test.

It was expressed at this time that it would be worthwhile to encourage their efforts by duplicate testing and evaluation.

Incorporation of improvements as suggested would result in a better and more economical product.

The first shelter was completed and shipped to the Signal Corps on May 2, 1963. On May 3, 1963 one (1) set of preliminary manufacturing drawings were submitted. It was the responsibility of the Signal Corps to test and evaluate the shelter construction. During these tests, Twin Industries' personnel were not present. The tests were conducted from May to August of 1963 by the Signal Corps Equipment Evaluation Branch. Results of tests conducted by the Signal Corps were indicated on the enclosed EDT Data Sheets (Enclosure # IV-11) submitted by the Equipment Evaluation Branch to Twin Industries Corporation upon request. Also forwarded were photographs of failing areas resulting from railroad humping tests.

It should be noted that prior to completion of the lightweight shelter, a weight comparison analysis was made, as were center of gravities. Our weight analysis indicated a weight empty of 323.4 pounds, including 18 pounds excess for shock skids and 5.4 pounds excess for longitudinal hat sections. Both of these items were not a part of the original 300-pound estimate.

As shown on Enclosure # IV-10 , the actual weight is 342 pounds, or 18.6 pounds over the calculated analysis. The additional weight was due to a combination of the following:

a. Increase in side panel skin thickness because desired thickness was not readily available.

b. Skin splices were necessary because sheets of sufficient size were not readily available.

c. Stress analysis indicated the need for doubler strips along some of the thin gage skin edges to give more hold to rivets.

d. Door hinges and latches weigh more than catalog weights.

e. The use of adhesive, sealer and paint was excessive.

The hoist sling, payload mounting rails and dummy payload was not included in the shelter weight.

The Lightweight Shelter Status as of May 22, 1963 was as follows:

a. Test Shelter No. 1 and one (1) set of preliminary manufacturing drawings was shipped to Fort Monmouth May 3, 1963.

b. Signal Corps estimated 120 days to test Shelter No. 1. Twin Industries was to provide test assistance as requested and eliminate possible failures by re-design and repair until tests were successfully completed. As of the date of the status, Twin Industries received no request for test assistance.

c. Upon acceptance of Shelter No. 1, Twin Industries was to make a set of final manufacturing drawings and produce Shelter No. 2 to those drawings. Shelter No. 2 was also to be tested at Fort Monmouth. Signal Corps estimated a 30-day test period. Twin Industries was also to provide test assistance as requested, and make re-designs and repairs as necessary. Upon completion, Twin Industries was to furnish a complete up-to-date set of manufacturing drawings.

d. Twin Industries was to furnish nine (9) progress reports and one (1) final report. Four (4) progress reports were submitted, and the remainder were not required.

e. The number and spread of engineering hours required to complete the program depended upon the success and duration of the test program controlled by the Signal Corps. The following is a rough engineering hour estimate depending on the above conditions:

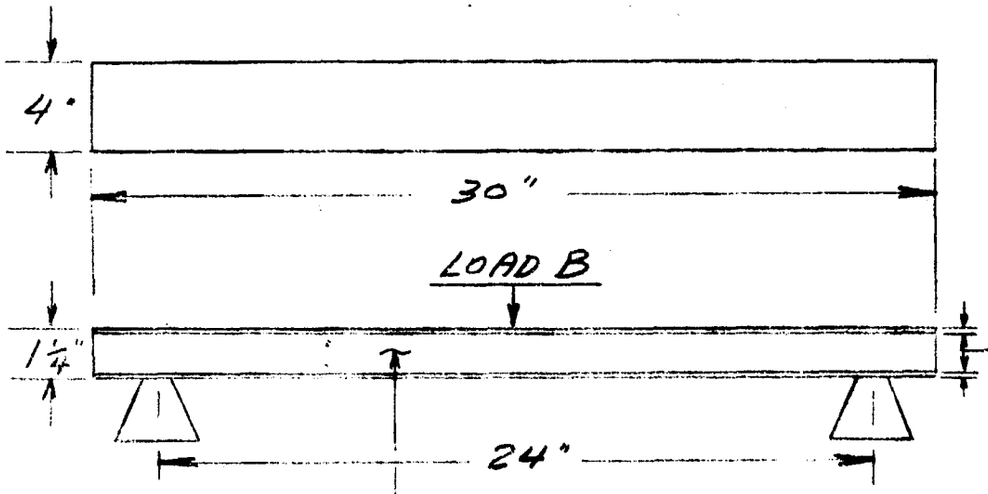
1.	Shelter No. 1 Test/Liaison, Re-design, Repair	240 hrs.
2.	Final Manufacturing Drawings	200 hrs.
3.	Shelter No. 2 Manufacturing Liaison	80 hrs.
4.	Shelter No. 2 Test Liaison, Re-design, Repair	120 hrs.
5.	Up-date Final Manufacturing Drawings	80 hrs.
6.	Prepare Reports	60 hrs.
	TOTAL	780 hrs.

ENCL IV-1

(20)

SCL-4366 LIGHTWEIGHT SHELTER,

SANDWICH PANEL BOW TEST.

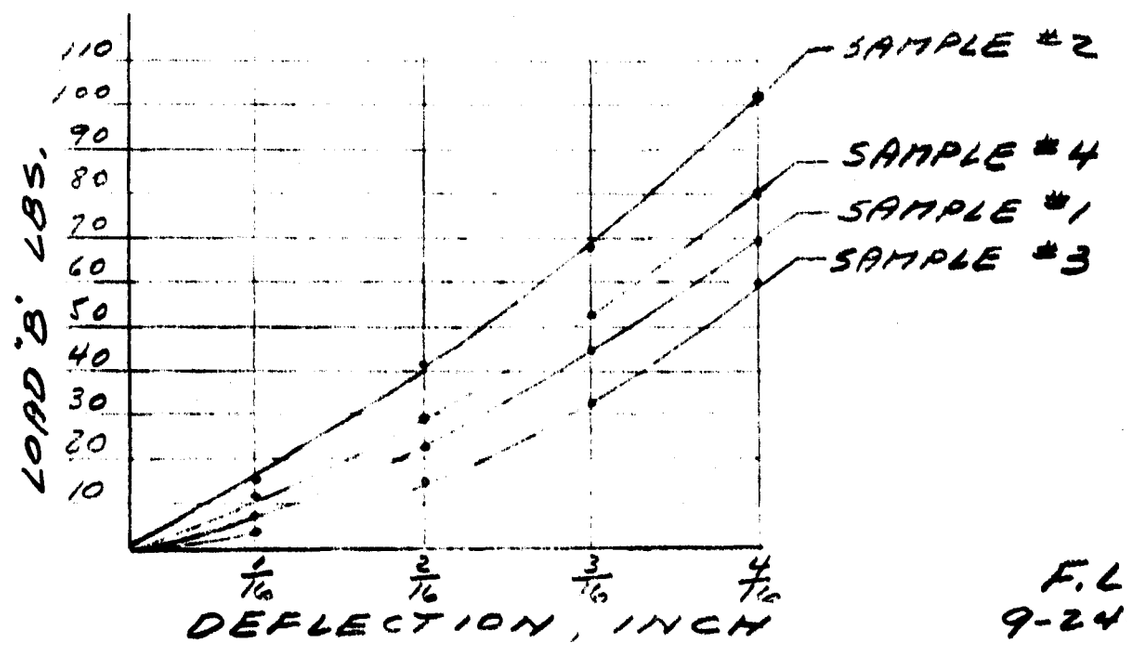


ADHESIVE:
PALMER #830A
&
VERSAMID #140

.016" SHEET
7075-T6

SAMPLE Nº	FOAM CORE		
	TYPE	DENSITY	"K" FACT.
1	DYFOAM	1.5 LB	.25
2	STYROFOAM	2.0 "	.25
3	ZER-O-CEL	1.5 "	.15
4	ZER-O-CEL	2.0 "	.15

SAMPLE # 2
SELECTED.
(ALSO SEE DATA AND SELECTION ON SHEET 2L)



F.L.
9-24-62

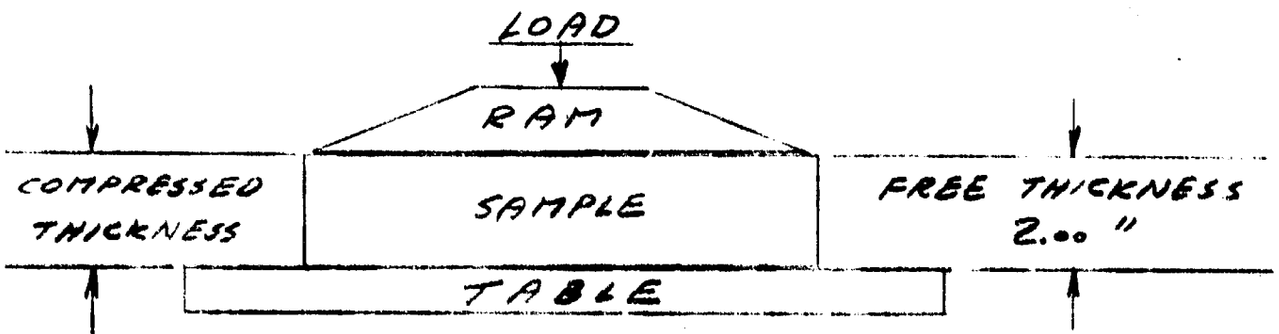
ENCL IV-1

(2.b)

SCL-4366 LIGHTWEIGHT SHELTER

FOAM CORE COMPRESSION TEST.

SIZE OF TEST SAMPLE: 4" SQUARE X 2" THICK.
ALL SAMPLES CUT FROM 2" SLABS.
NO SKIN BONDED TO SAMPLES.



		SAMPLE 1. DYFOAM 1.5 LB. DENS.		SAMPLE 2 STYROFOAM 2 LB. DENS.		SAMPLE 3 ZER-O-CEL 1.5 LB. DENS.		SAMPLE 4. ZER-O-CEL 2 LB. DENS.	
		LOAD	SET	LOAD	SET	LOAD	SET	LOAD	SET
INCH	%	LBS	%	LBS	%	LBS	%	LBS	%
1.75	12.5	330	6.2	800	3	270	3	350	3
1.5	25.0	430	12.5	830	12.5	300	9.2	380	6.2
1.25	37.5	540	22	840	22	340	12.5	430	9
1.00	50.	670	28	960	25	420	18.5	510	18.5
.75	62.5	860	34.5	1240	28	510	21.8	620	25

MATERIAL PER SAMPLE #2 SELECTED.
(ALSO SEE DATA AND SELECTION ON SHEET 2a)

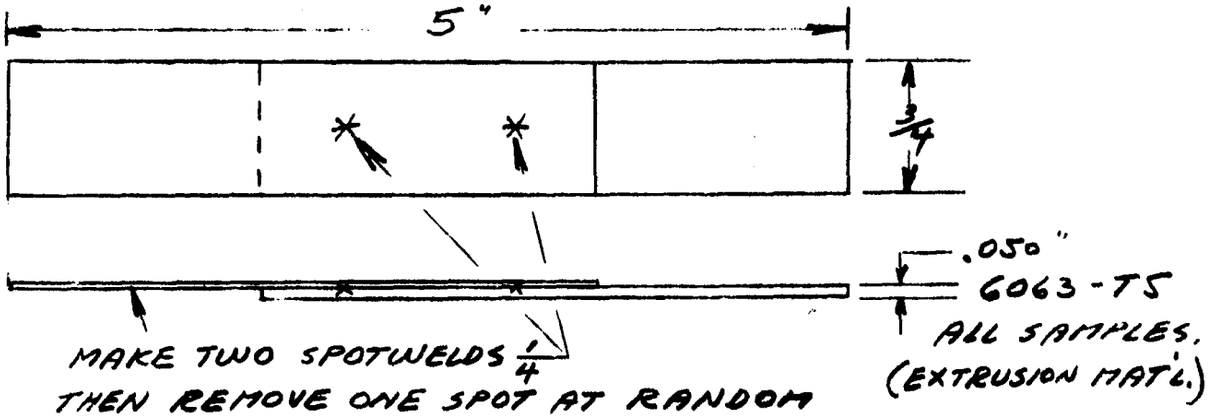
F.L.
9-25-62

ENCL IV-2

(2c)

SCL-4366 LIGHTWEIGHT SHELTER

SKIN SPOTWELD PULL TEST



SAMPLE NO.	MATERIAL	THICK-NESS	PULL TO FAIL. LB/SPOT	ALCOA BOOK MIN. SHEAR LB/SPOT	TYPE OF FAILURE	NOTE
1	2024-T3 ALCLAD	.016"	125	108	SHEAR	
2	5052-H32	.016	260	98	PULLOUT	
3	6061-T6 ALCLAD	.016	200	98	SHEAR	
4	7075-T6 ALCLAD	.016	359	108	PULLOUT	1
5	2024-T3 ALCLAD	.020	400	140	SHEAR	
6	5052-H32	.020	315	132	PULLOUT	
7	6061-T6 ALCLAD	.020	265	132	PULLOUT	
8	7075-T6 ALCLAD	.020	425	140	PULLOUT	2
9	2024-T3 ALCLAD	.032	550	260	PULLOUT	
10	5052-H32	.032	465	235	SHEAR	3
11	6061-T6 ALCLAD	.032	372	235	SHEAR	
12	7075-T6 ALCLAD	.032	500	260	SHEAR	

MATERIAL SELECTED FOR:

1. ROOF PANEL SKINS AND ALL INNER SKINS ABOVE SHELF LINE.
2. SIDES AND ENDS OUTER SKINS. INNER SKINS BELOW SHELF LINE.
3. OUTER SKIN, BOTTOM AND SHELF.

F.L.
9-24-62

ENCL IV-3

Temporary Engineering Release

TWIN COACH CO.
AERO SPACE DIV.
BUFFALO, N. Y.

No 1

DATE 4-26-62

By W.C.C

Sheet 1 of

SHELTER - THIN WALL - LIGHT WEIGHT

WEIGHT ANALYSIS

① Alum. Skins

Roof - .016 - 2024-T6 @ .230 #/sq.ft

Area = $\frac{71 \times 73}{144} \times 1$ = 36 sq.ft.

wgt = 2 × 36 × .230 (inner & outer) = 16.6 #

Outer Floor - .031" - 5052-H34 @ .433 #/□

Area = $\frac{71 \times 73}{144} + \frac{2 \times 19 \times 24}{144}$

= 36 + 19.5 = 55.5 □ wgt = 55.5 × .433 = 24.9 #

Inside bottom floor - .031" - 2024-T6 @ .446 #/□

Area = $\frac{44 \times 72}{144} \times 1$ = 22 □ wgt = 22 × .446 = 9.8 #

Inside floor sides & step - .020 - 2024 T6 @ .288 #/□

Area = $\frac{2 \times 19 \times 72}{144} + \frac{2 \times 14.5 \times 72}{144}$

= 19 + 14.5 = 33.5 □

wgt = 33.5 × .288 = 9.7 #

Ends - outside - .025 - 2024-T6 @ .360 /□

Area = $\frac{2 \times 44 \times 73}{144} + \frac{2 \times 19 \times 44}{144}$

= 44.5 + 11.6 = 56.1 □, wgt = 56.1 × .360 = 20.2 #

ENDS - Inside - .020 - 2024-T6 @ .288 #/□

Area = ditto outside = 56.1 □ wgt = 56.1 × .288 = 16.2 #

Sides - Outer - .025" - 2024-T6 @ .360 #/□

Area = $\frac{2 \times 42 \times 72}{144}$ = 42 □ wgt = 42 × .360 = 15.1 #

Sides - Inner .020 perforated alum. - 2024-T6 @ .144 #/□

Area = ditto outer wgt = 42 × .144 = 6.0

TOTAL 118.6

ENCL IV-3

Temporary Engineering Release

TWIN COACH CO.
AERO SPACE DIV.
BUFFALO, N. Y.

No _____

DATE _____

By _____

Sheet 2 of ____

(3) STRUCTURAL MEMBERS

Std ⌐L (drg. 26600) for center members on roof, floor, & ends - wgt. .38#/FT.
60 FT req'd = 22.8#

Std ⌐L (drg.) for ends - wgt. .85#/FT
49 FT req'd = 42.0#

Wall center members L - wgt. .20#/FT
6061-T6
15 FT req'd = 3.0#

TOTAL = 67.8#

(5) Insulation

Foam for roof, ends, & floor @ 2#/ft³.
Area = 36 + 56. + 55.5 ≈ 148 ft²
wgt. $148 \times \frac{1.25}{12} \times 2$ = 31.0#

Fiberglass for sides - Armalite - .7#/ft³
Area : 42 ft² wgt. $42 \times \frac{1.25}{12} \times .7$ ≈ 4.0#

TOTAL = 35.0#

(4) Doors & frame

door frame ⊐ wgt. = .36#/ft
14 FT req'd = 5.0#

doors - add incremental outer skin difference
partially included in end panel
mat. .060" Al. 5052-H34 Δwgt. .446#/ft²
Area : $\frac{32 \times 48}{144}$ = 15 ft² = 6.5#

TOTAL 11.8#

ENCL IV -3

TWIN COACH CO.
AERO SPACE DIV.
BUFFALO, N. Y.

Temporary Engineering Release

No _____

DATE _____

By _____

Sheet 3 of ____

(1) EPOXY FOR sandwich panels = 70 #/ft³

TOTAL Area = 148 ☐

wgt. = $\frac{2 \times 148 \times .008'' \times 70}{12}$ = = 14.0 #

(2) Corner covers - ⌐ - 6061-T6, .060, .89 #/D

Area = $\frac{4 \times 24 \times 5}{144}$ = 10.3 # = 9.2 #

(7) SKIDS - .062" - 6061-T6

Area = $\frac{7 \times 24}{144} \times 2$ = 7.2 ☐ = 6.4 #

(9) FLOOR & Roof mtg members - .090" - 2024-T6 @ 1.30 #/ft²

$41 \times \frac{3 \times 22}{144}$ = = 7.9 #

(8) Sealer - 1/2 gal. 4.0 #

(10) Rivets & Hardware 5.0 #

(11) Tow Eyes 3.0 #

(12) Lift Eyes 3.0 #

(13) door latches & handles (2 sets) 5.0 #

(14) Hinges 5.5 #

(15) WOOD 3.0 #

ENCL IV - 3

Temporary Engineering Release

TWIN COACH CO.
AERO SPACE DIV.
BUFFALO, N. Y.

No _____

DATE _____

By _____

Sheet 4 of ____

(16)	Paint	5.0 lbs
(17)	steps	2.5 lbs
	TOTAL SHELTER WGT.	298.6 lbs

ENCL IV-4

Temporary Engineering Release

TWIN COACH CO.
AERO SPACE DIV.
BUFFALO, N. Y.

No _____

DATE 4-23-62

By WEC

Sheet 1 of ____

SHELTER - THIN WALL - LIGHT WEIGHT

PRELIM. STRESS ANALYSIS

SCL-4366

(1) ROOF LOADING - TP 4.4.5

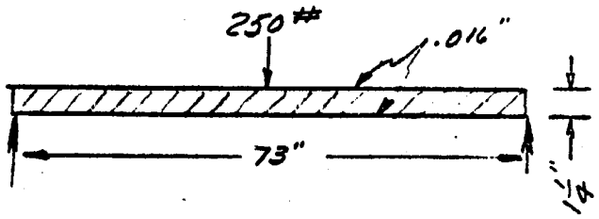


FIG. 1

$I = 2Ad^2$

For 2" wide sect.

$I = 2 \times 2 \times .016 \times .625^2$

$= .025 \text{ in}^4$

Assume load per Fig. 1 for 2" beam

$S = \frac{250 \times 73 \times .625}{4 \times .025} = 71,500 \text{ psi}$

However Spec. calls for 12" section

$\therefore \frac{71,500}{6} = 11,900 \text{ psi}$ - OK

since no consideration taken for effect of lateral beam & internal structurals & distribution of load over 12" - actual stress ≈ 1/3 11,900 ≈ 4000

(2) FLOOR LOAD

$S = \frac{44}{73} \times 71,500 = 43,000 \text{ psi}$ for 2" beam

$= 7,166$ " " 12" " OK

NOTE

. max. stresses permissible determined by foam physicals. For 2nd Down coming stiffs foam - $S_{b\,max}$ 1500 psi in sandwich construction.

ENCL IV - 4

Temporary Engineering Release

TWIN COACH CO.
AERO SPACE DIV.
BUFFALO, N. Y.

No _____
DATE _____
By WEC
Sheet 2 of ____

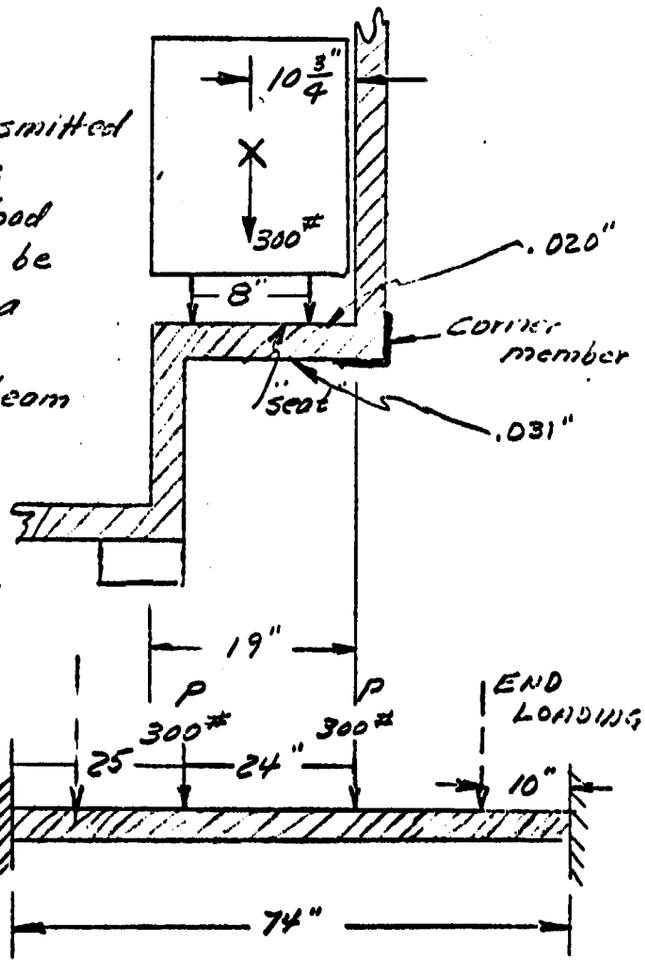
PRELIM - STRESS ANALYSIS

③ LOADINGS Under 18" drop

FOR CENTER LOADS -

Part of load will be transmitted directly into SKID THRU the stepped wall. Balance of load will act on "seat" and will be transmitted to ends as per a fixed end beam.

∴ % of Load acting on beam is assumed @ 50%



FOR 18" drop assume instantaneous deflection in SKIDS, side walls & beam @ 1½"

∴ G's: $\frac{18 \times 2}{1.50} \approx 24$

I for "seat" as beam

$= 19(.020 \times .62^2 + .031 \times .62^2)$

$= 19(.0077 + .0119) = .372\ in^4$

$S = \frac{150 \times 24 \times 25 \times .62}{.372} = 146000\ psi$ - TOO HIGH

However - part of load is picked up by step Cantilever

$1500 = \frac{P \times 24 \times (19 - 10\frac{3}{4}) \times .62}{.372}$

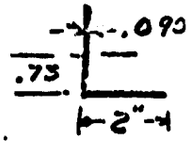
I taken for 19" length of beam ∴ .372

$P = 46^{\#}$

Additional load is picked up by corner member

$I = \frac{.090 \times 2^3}{12} + .09 \times 2 \times .27^2 + 2 \times .09 \times .68^2$

$= .06 + .013 + .083 = .156\ in^4$



ENCL IV-4

Temporary Engineering Release

TWIN COACH CO.
AERO SPACE DIV.
BUFFALO, N. Y.

No _____
DATE _____
By WEC
Sheet 3 of ____

PRELIM. STRESS ANALYSIS

max. allowable stress = 60,000 psi

$$60{,}000 = \frac{P \times 24 \times 25 \times .73}{.156}$$

$P = 21$ #

Additional load is picked up by side wall & roof however considering effect of cantilever & L beam

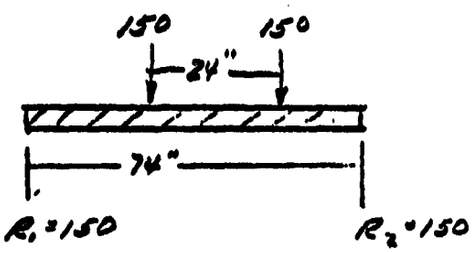
$P_{balance} = 150 - 21 - 46 = 83$#

$$S_{for\ seat} = 146000 \times \frac{83}{150} = 80{,}000\ psi - HIGH$$

This will result in additional deflection which will attenuate shock to less than 24 G's
MUST BE CHECKED FOR SHOCK INPUT

FOR END LOADS:- Opposite side considering beam only

$$S = \frac{150 \times 24 \times 10 \times .62}{.372} = 56{,}000\ psi - OK$$



④ End Panel
FOR 24 G's: $P = 150 \times 24 = 3600$#

End panel skin shear loading per 1/4 rivet

$A = .250 \times .025 = .0063$

$$S_s = 40000 = \frac{3600}{n \times .0063}$$

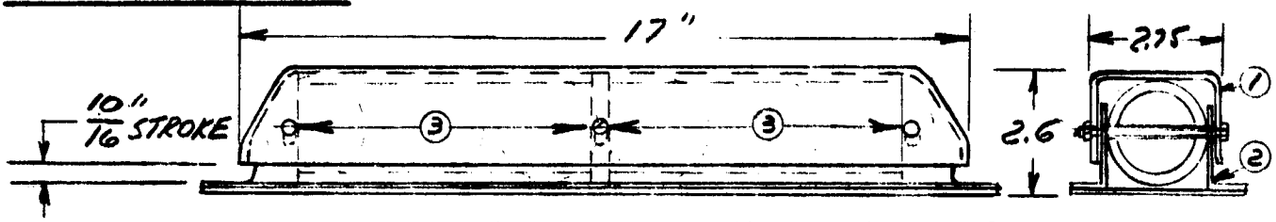
$n = 14$ rivets - OK

SCL-4366 LIGHTWEIGHT SHELTER
JOB # A9
SHOCK SKID STATIC LOAD TEST.

TEST OBJECTIVE: TO DETERMINE THE DIFFERENCE IN LOAD BEARING CAPACITY OF A DUTHANE PLASTIC TUBE, WHEN LOCATED INSIDE AN AL. TELESCOPING CHANNEL,
1. IN LINE WITH THE SKID CENTERLINE,
2. ACROSS THE SKID CENTERLINE.

TEST RESULT: A TUBE, PLACED IN LINE WITH THE SKID CENTERLINE WILL TAKE APPROX. TWICE THE LOAD. HOWEVER, THIS METHOD DEMANDS A SQUARE CROSS SECTION OF THE SKID CHANNEL BUT METHOD #2 DOES NOT.

TEST SAMPLE #1.



1. SKID CHANNEL, .062 AL. SHEET 6061-T6
2. SUPPORT ANGLE, .062 AL. SHEET 7075-T6
3. DUTHANE TUBE, 96 DUROMETER (SHORE) 2 PIECES, EACH 2.5" O.D. X 2.0 I.D. X 7.5" LONG, 15 INCH TOTAL.

TEST SAMPLE #2.

IDENTICAL TO SAMPLE #1 EXCEPT:
DUTHANE TUBE, 6 PIECES, EACH 2.5" O.D. X 2.0 I.D. X 2.5" LONG, 15 INCH TOTAL.

LOAD CALCULATION: THE TOTAL LENGTH OF SHOCK ABSORBING TUBE PER SHELTER (2 SKIDS) WILL BE 140 LINEAR INCHES, EITHER METHOD. ASSUMING A SHELTER WEIGHT OF 300 LBS AND PAYLOAD OF 1200 LBS WE HAVE A STATIC LOAD OF 10.7 LBS PER LINEAR INCH OF TUBE.

D. CLINE
R. GEIGER

F. LAKOWITZ
10-18-62

7 31 17 & 15

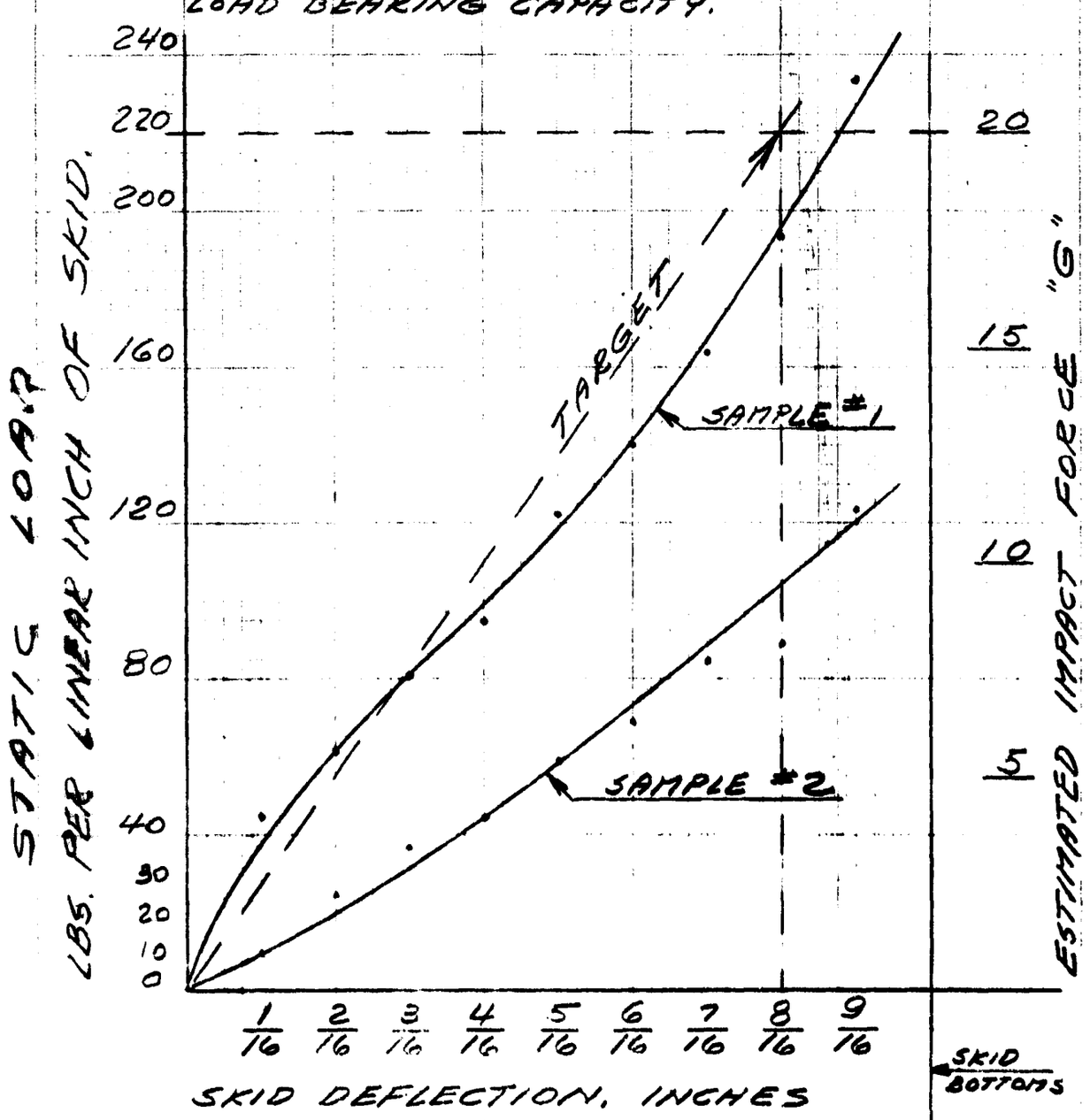
SCL-4366 LIGHTWEIGHT SHELTER.
JOB #A9.

ENCL III-7

SHOCK SKID STATIC LOAD TEST.

SEE SHEET 3 FOR DESCRIPTION OF TEST SAMPLES.

TEST RESULT: LOAD BEARING CAPACITY OF SAMPLE #1 IS SATISFACTORY.
SHOCK ABSORBER TUBE LENGTH OF SAMPLE #2 WOULD HAVE TO BE DOUBLED TO GET LOAD BEARING CAPACITY.

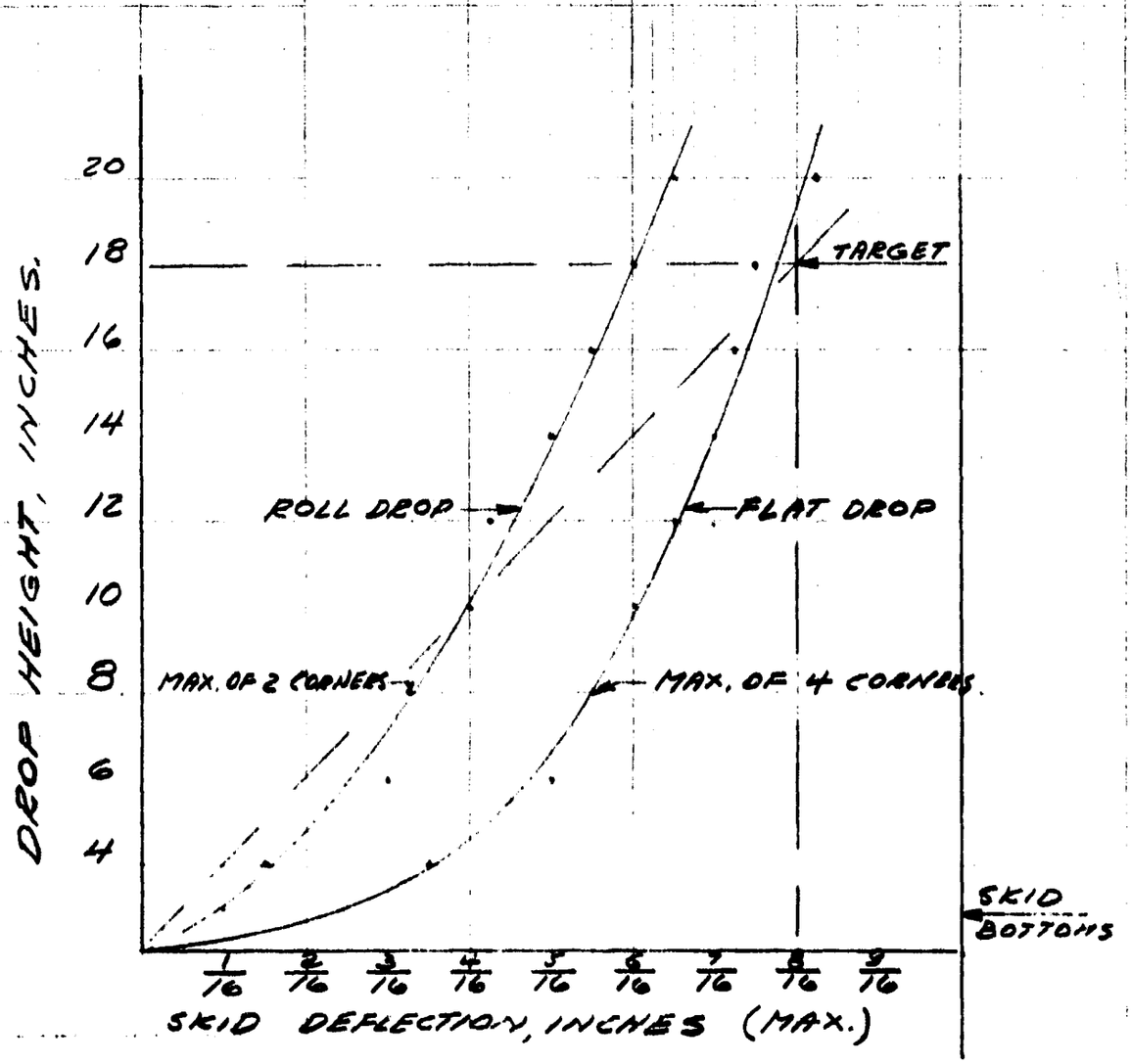


F.L.
10-18-62

SCL-4366 LIGHTWEIGHT SHELTER.
JOB #A9.
ENCL IV-8

SHOCK SKID DROP TEST.

TEST SET UP: TWO SKID SAMPLES, PER SAMPLE #1, SHEET 3, WERE MOUNTED (36" APART) TO THE LOWER SURFACE OF A BOILER PLATE 1.5 X 18 X 48 INCHES. THE RIG WAS EQUIPPED WITH ONE MECHANICAL INDICATOR NEAR EACH SKID END TO MEASURE SKID DEFLECTION AFTER EACH DROP. A HOIST SLING WITH QUICK RELEASE HOOK WAS USED TO DROP THE RIG TO THE CONCRETE FLOOR. STATIC LOAD WAS 12.5 LBS. PER LINEAR INCH OF DUTHANE TUBE. (RIG 375 LBS ÷ 30" OF DUTHANE TUBE) THE RIG WAS NOT EQUIPPED TO MEASURE IMPACT" (G)



ENCL IV-9

4-29-63.

JOB #A9 LIGHTWEIGHT SHELTER.
ROOF PANEL DWG. # E31505,
STATIC TEST.

PANEL WAS PLACED HORIZONTALLY UPON A STEEL STRUCTURE WHICH SUPPORTED THE PANEL ALONG EACH OF IT'S FOUR EDGES SIMILAR TO THE FOUR WALLS OF THE SHELTER.
PANEL DEFLECTION AT THE PANEL CENTER WAS CAREFULLY MEASURED BEFORE LOADING, AFTER LOADING, AND AFTER REMOVAL OF THE LOAD.
THERE WAS NO DEFORMATION OR ANY TYPE OF DAMAGE TO THE PANEL AFTER TEST.

TEST #1, ROOF TEST, SPEC. SCL-4366 PAR. 4.4.5
A 250 LB CONCENTRATED LOAD ON ONE SQUARE FOOT OF AREA WAS APPLIED AT THE CENTER OF THE PANEL.
THIS LOAD CAUSED THE PANEL TO DEFLECT 3/16 INCH.
AFTER REMOVAL OF THE LOAD, THE PANEL RETURNED TO ITS NORMAL STRAIGHTNESS.

TEST #2, SNOW LOAD TEST, SPEC. SCL-4366, PAR. 4.4.11.4.
THE PANEL WAS LOADED WITH 1500 LBS OF SAND BAGS UNIFORMLY DISTRIBUTED OVER THE ENTIRE AREA. (40 LBS PER SQ. FT.)
THIS LOAD CAUSED THE PANEL TO DEFLECT 5/16 INCH.
AFTER REMOVAL OF THE LOAD, THE PANEL RETURNED TO ITS NORMAL STRAIGHTNESS.

JOB A9. LIGHTWEIGHT SHELTER. DWG. 31500.

COMPARISON, CALCULATED VS. ACTUAL WEIGHT. ENCL IV-10

1. COMPONENTS

DWG. Nº	UNIT QTY	NAME OF COMPONENT	WEIGHT ANALYSIS DATED FEB. 11, 63	WEIGHT ACTUAL AS MADE
31500	1	SHELTER ASSEMBLY HARDWARE	41.7	44.0
31501	1	FLOOR & SHELF ASSEMBLY	89.8	95.4
31502	1	FRONT END ASSEMBLY	25.9	25.5
31503	1	DOOR END ASSEMBLY	20.9	22.3
31504	2	SIDE PANEL ASSEMBLY L/R	38.8	45.6
31505	1	ROOF PANEL ASSEMBLY	45.7	47.5
31506	2	SHOCK REDUCING SKIDS	24.8	26.0
31507	1	MAIN & AUX. DOOR ASSEMBLY	35.8	35.7
		TOTAL LBS.	323.4	342.0

2. MATERIAL TYPE

SKINS. AL. SHEETS FOR IN & OUTSIDE	107.2	113.2
STRUCTURE. EXTRUSIONS, FORMED SECTIONS, DOUBLERS	97.9	100.4
INSULATION. FOAM, FIBREGLASS, TAPE.	30.2	30.5
WOOD. HEMLOCK PLYWOOD, OAK FILLER BLOCKS	12.5	13.7
STEPS, LIFT EYES, TOW RINGS, HINGES, LATCHES.	19.5	21.6
RUBBER SEALS, SHOCK ABSORBERS,	12.0	13.9
SCREWS, BOLTS, RIVETS, NUTS, WASHERS,	6.5	7.8
ADHESIVE	16.1	17.6
SEALER	6.5	7.5
PAINT & FLOOR COVERING	15.0	15.8
TOTAL LBS.	323.4	342.0

F. BATSON
R. GEIGER
M. DAIBER

F. L.
5-10-63.

Temporary Engineering Release

No ____ DATE ____ By ____ Sheet ____ of ____

TWIN INDUSTRIES CORPORATION
AERO SPACE DIVISION
BUFFALO, N.Y.

JOB # A9 LIGHTWEIGHT SHELTER SKINS.

ENCL IV-10

DWG.	ITEM	QTY	LOCATION	SIZE	MAT'L	REF.
31500	15	4	CORNER COVER	.062 X 7.5 X 74.2	7075 - T6	DWG. 31512
31501	1	1	FLOOR, OUTER	.032 X 72.75 X 110	6061 - T6	DWG. 31514
31501	8	1	FLOOR, INNER	.025 X 42.9 X 70.5	7075 - T6	
31501	10	2	STEP, INNER	.020 X 33.62 X 70.5	7075 - T6	
31501	29	2	SKID REINFORCEMENT	.062 X 3.125 X 74	7075 - T6	
31502	1	1	FRONT END, OUTER	.020 X 62.5 X 72.5	7075 - T6	SPLICE
31502	14	1	" " INNER, LOWER	.016 X 22.5 X 72.5	7075 - T6	
31502	15	1	" " INNER, UPPER	.016 X 40.5 X 74	7075 - T6	PERFORATE
31503	1 & 2	2	DOOR END, OUTER	.020 X 62.5 X 21	7075 - T6	
31503	24	2	" " INNER LOWER	.016 X 22.5 X 22	7075 - T6	
31503	25	2	" " INNER UPPER	.016 X 22 X 40.5	7075 - T6	PERFORATE
31504	1	2	SIDE 1/2, OUTER	.020 X 42 X 72.75	7075 - T6	USE .025 TO AVOID SPLICING
31504	6	2	" " INNER	.016 X 42 X 71	7075 - T6	PERFORATE
31505	2	1	ROOF, OUTER	.016 X 70.75 X 72.75	7075 - T6	SPLICE
31505	3	1	" INNER	.016 X 70.5 X 70.5	7075 - T6	SPLICE
31507	1	1	DOOR, MAIN, OUTER	.032 X 29.5 X 62	5052 - H32	
31507	9	1	" " INNER	.032 X 32 X 65	5052 - H32	
31507	10	1	" AUX, OUTER	.032 X 21.5 X 37.5	5052 - H32	
31507	16	1	" " INNER	.032 X 24 X 40	5052 - H32	

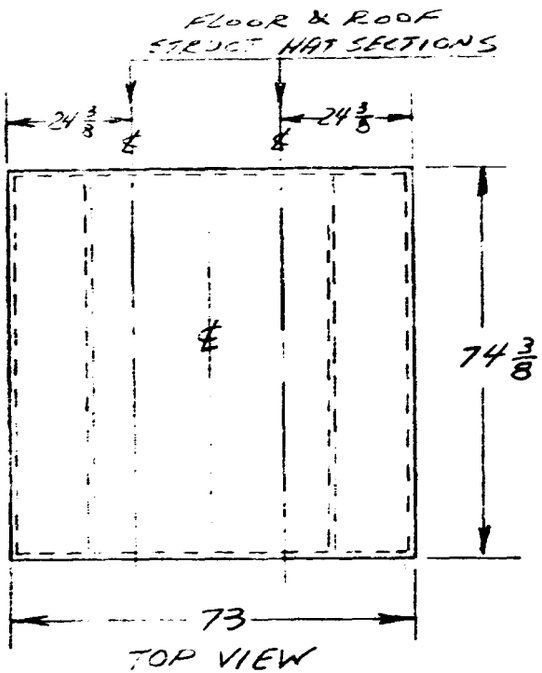
ENCL IV-10

LIGHTWEIGHT SHELTER SCL-43166

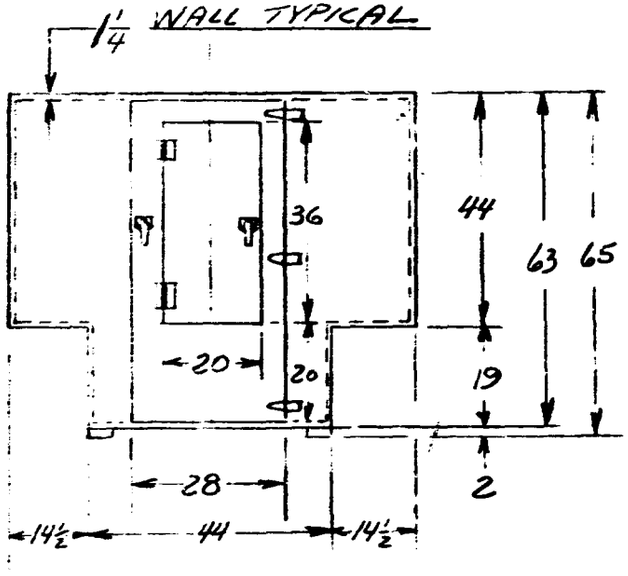
A = C.G. OF DUMMY LOAD = 1200 LBS. x 22 3/16 = 26625

B = C.G. OF EMPTY SHELTER = 340 LBS. x 34 3/4 = 11 815

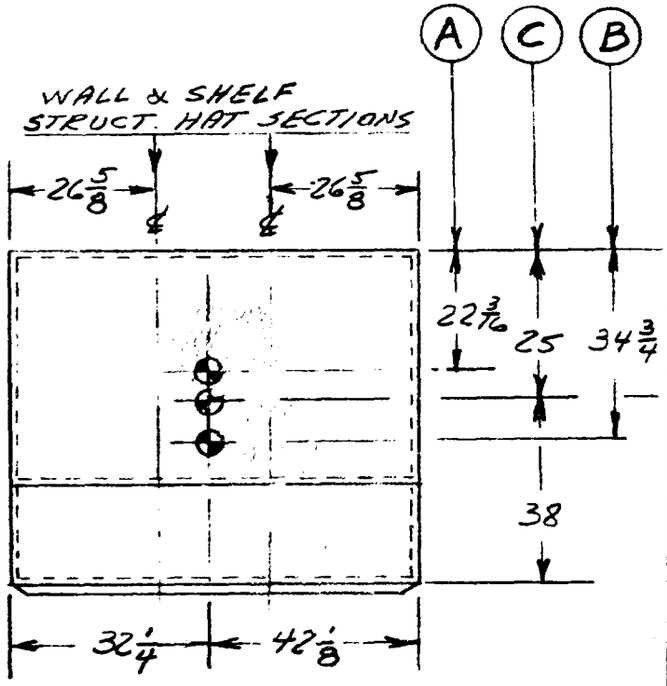
C = C.G. OF GROSS WEIGHT = 38440 ÷ 1540 = 25.00"



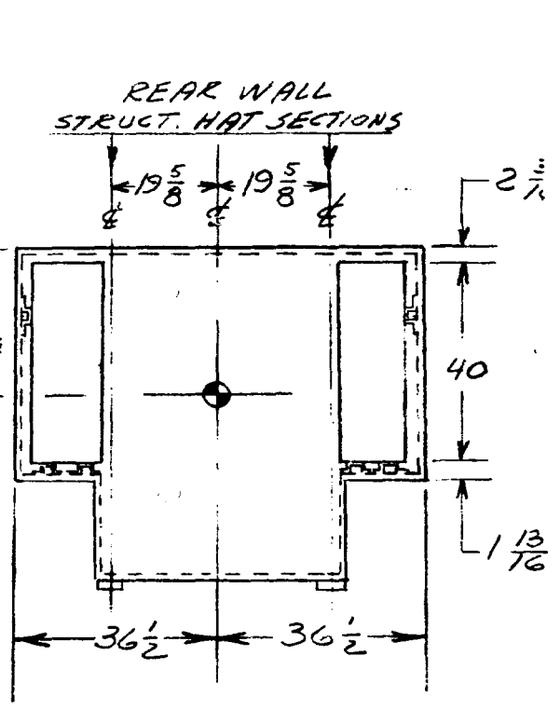
TOP VIEW



REAR VIEW



SIDE VIEW



FRONT VIEW

ENCL IV-11-1

EDT DATA SHEET

ITEM UNDER TEST (XE-), SER. NO. —	SHELTER, THINWALL, LIGHTWEIGHT
PART OF/OR USED WITH (XE-), SER. NO.	
IDENTIFICATION	MIL-S-52060 (SIGC) 5 OCT 62
TESTING ACTIVITY	EQUIP. EVAL. BR.
TYPE OF TEST	TOWING EYE TEST

1.0 REQUIREMENT: ¶ 3.4.2

2.0 PROCEDURE: ¶ 4.13.2

3.0 RESULTS: No damage was done to the shelter towing eyes during these tests.

4.0 DISCUSSION: This test was requested by the project engineer in anticipation of future inclusion in the requirements for the subject shelter.

EQUIPMENT COMPLIED X	TESTED BY USAELRDL	TEST COMPLETED 2? JULY 63
EQUIPMENT DID NOT COMPLY	WITNESSED BY M. Deutschman	ISSUE DATE
		Page of of Appendix

ENCL IV-11-2

EDT DATA SHEET

ITEM UNDER TEST (XE-), SER. NO.
SHELTER, THINWALL, LIGHTWEIGHT

PART OF/OR USED WITH (XE-), SER. NO.

IDENTIFICATION MIL-S-52060 (SIG C) 5 OCT 62

TESTING ACTIVITY EQUIP. EVAL. BR.

TYPE OF TEST LIFTING EYE TEST

1.0 REQUIREMENT: ¶ 3.6.1

2.0 PROCEDURE: ¶ 4.13.1

3.0 RESULTS: No damage was done to the shelter lifting eyes during these tests

4.0 DISCUSSION: This test was requested by the project engineer in anticipation of future inclusion in the requirements for the subject shelter.

EQUIPMENT COMPLIED X	TESTED BY USAELRDL	TEST COMPLETED 2 JULY 63
EQUIPMENT DID NOT COMPLY	WITNESSED BY M. Deutschman	ISSUE DATE
		Page of of Appendix

DA FORM [illegible], which may be used until exhausted. Army-Ft Monmouth, NJ-MON 1824-63

incl 9

ENCL IV-11-3

EDT DATA SHEET

ITEM UNDER TEST: SHELTER, THINWALL, LIGHTWEIGHT (XE-), SER. NO. —

PART OF/OR USED WITH: (XE-), SER. NO.

IDENTIFICATION: MIL-S-52060 (SIG.C) 5 Oct 62

TESTING ACTIVITY: EQUIP. EVAL. BR.

TYPE OF TEST: WALL -- STATIC LOAD TEST

1.0 REQUIREMENT: ₱ 3.10

2.0 PROCEDURE: ₱ 4.18.1

3.0 RESULTS: The shelter walls showed a definite buckling pattern as the load was applied. At 850 lb. pull on the wall insert the shelter wall buckled with practically no additional load. The test was terminated at this point to prevent further damage to the shelter.

EQUIPMENT COMPLIED ☐	TESTED BY USAELRDL	TEST COMPLETED 2 AUG 63
EQUIPMENT DID NOT COMPLY X	WITNESSED BY Mr Deutschman	ISSUE DATE
		Page of of Appendix

SELRA Form 1408 (Replaces FMBC-8683, which may be used until exhausted) Army-Ft Monmouth, NJ-MON 192A-63

ENCL IV-11-4

EDT DATA SHEET

ITEM UNDER TEST (XE-), SER. NO.
SHELTER, THINWALL, LIGHTWEIGHT — —

PART OF/OR USED WITH (XE-), SER. NO.

IDENTIFICATION: SCL-4366 (5 DEC 61)

TESTING ACTIVITY: EQUIP. EVAL. BR.

TYPE OF TEST: SNOW LOAD TEST

1.0 REQUIREMENT: ¶ 3.9d

2.0 PROCEDURE: ¶ 4.4.11.4

3.0 RESULTS: Some deflection of the shelter roof was noted during the test. Removal of the load, which consisted of water poured into a wood-frame braced polyethylene liner, restored the shelter to its original shape. No permanent damage was observed.

EQUIPMENT COMPLIED X	TESTED BY USAELRDL	TEST COMPLETED 18 JULY 63
EQUIPMENT DID NOT COMPLY ☐	WITNESSED BY M. Deutschman	ISSUE DATE
		Page of of Appendix

SELRA Form 1008, (Replaces FMSC-8689, which may be used until exhausted) Army-Ft Monmouth, NJ-MON 152A-63

Incl 4

ENCL IV-11-5

EDT DATA SHEET

ITEM UNDER TEST (XE-), SER. NO.
SHELTER, THINWALL, LIGHTWEIGHT —

PART OF OR USED WITH (XE-), SER. NO.
—

IDENTIFICATION
SCL - 4072A (24 OCT 61)

TESTING ACTIVITY
EQUIP. EVAL. BR.

TYPE OF TEST
RAILROAD HUMPING TEST

1.0 REQUIREMENT: MP 3.13.4 The shelter with full payload, shall be capable of being transported on a standard 40 ft. flatcar as used in Continental United States of america. During rail transport, the shelter shall be capable of being blocked, loaded and braced in accordance with the minimum methods and standards set forth in the loading rules pamphlet of the Association of American Railroads. The loaded shelter shall be capable of withstanding humping speeds of nine mph with no permanent deformation of the shelter.

2.0 PROCEDURE: MP 4.4.12 The shelter, loaded with metal dummy loads used to simulate weight distribution present in normal equipment loading, shall be loaded on a railroad flatcar in the manner commonly used for shipment, and impacted against stationary cars at a minimum velocity of nine mph. There shall be a minimum ratio of 5 to 1 of stationary mass. Four tests shall be performed, two with the shelter positioned longitudinally to the flatcar, and two positioned latterally.

EQUIPMENT COMPLIED	TESTED BY A. P. O.	TEST COMPLETED 11 MAY 63
EQUIPMENT DID NOT COMPLY X	WITNESSED BY M. Blatchman	ISSUE DATE
		Page 1 of 2 of Appendix

SELRA Form 1008 (Replaces ...) 1 Jan 63 ... Army-Ft Monmouth, NJ-MON 152A-63

EQP. SHELTER, THINWALL, LIGHTWEIGHT	TEST RAILROAD HUMPING	DATE 11 JULY 63

CONTINUED

3.0 RESULTS: With the shelter positioned on the flatcar so that it was longitudinal to the direction of travel there was no observable damage.

With the shelter positioned on the flatcar so that it was lateral to the direction of travel, considerable damage resulted.

Photographs 1 thru 6 inclusive show damage to the shelter.

The areas marked "1" show damage to the right side of the shelter resulting during the third impact. The shelter was mounted laterally on the flatcar with the right side facing the impact end of the flatcar.

The areas marked "2" show damage to the left side of the shelter resulting during the fourth impact. The shelter was mounted laterally on the flatcar with the left side facing the impact end of the car.

SELRA Form 1008-1 1 Jun 63 Replaces ... which may be used until exhausted ... myer Ft Monmouth, NJ MON 1528-63

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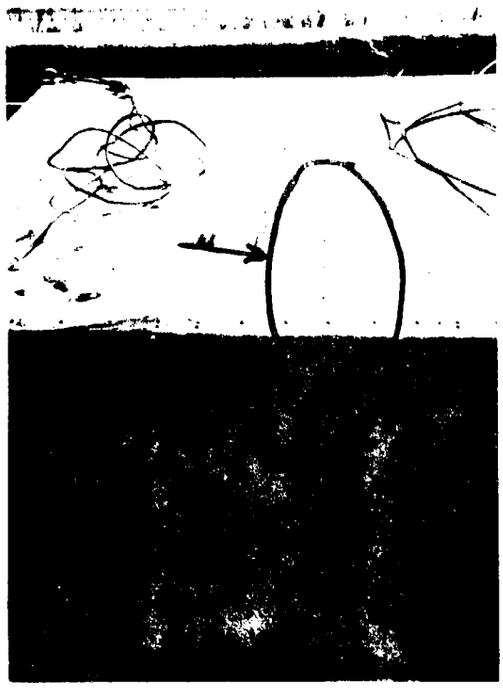


FIG. 1 AREA SHOWING THREE WELD POINTS IN SHELTER ROOF OPENED AS RESULT OF R.R. HUMPING TEST WITH SHELTER SECURED IN LATERAL POSITION ON FLATCAR.

FIG. 2 DAMAGE AREA "2" NEAR ROOF ANGLE OF SHELTER. SHELTER SECURED IN LATERAL POSITION ON FLATCAR FOR R.R. HUMPING TEST.

M-63-740

ENCL IV-11-5

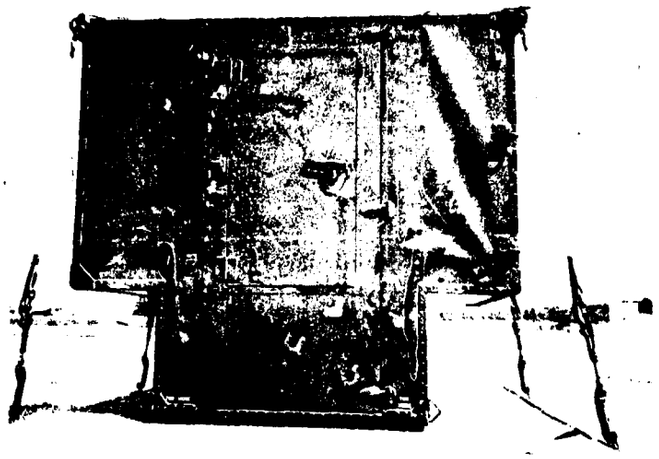


FIG. 3 DAMAGE AREAS "1" AND "2" AS RESULT OF R.R. HUMPING TEST. SHELTER POSITIONED LATERALLY ON FLATCAR. SHELTER ORIENTED WITH LEFT SIDE FACING IMPACTING FORCE FOR AREA "1" DAMAGE, AND AREA "2" FOR RIGHT SIDE FACING IMPACTING FORCE.

FIG. 4 ENLARGED VIEW OF FIGURE 3 SHOWING DAMAGE TO WELD POINTS ON LEFT REAR OF SHELTER.

FIG. 5 CLEARANCE AREA AT TOP OF SHELTER LARGE DOOR WIDENED AS RESULT OF R.R. HUMPING TEST.

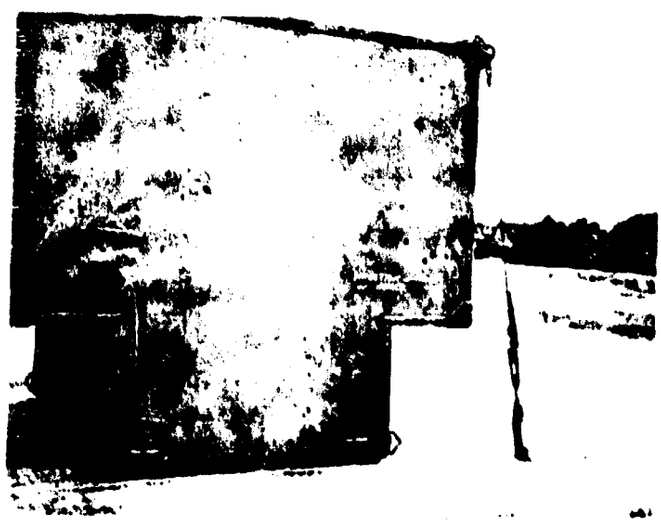


FIG. 6 DAMAGE TO SHELTER FRONT END, AREAS "1" AND "2", AS RESULT OF R.R. HUMPING TEST WITH SHELTER POSITIONED LATERALLY ON FLATCAR.

M-63-742

ENCL IV-11-6

EDT DATA SHEET

ITEM UNDER TEST: SHELTER, THINWALL, LIGHTWEIGHT (XE- —), SER. NO. —

PART OF/OR USED WITH: ——— (XE-), SER. NO.

IDENTIFICATION: SCL 4366 (5 DEC 61)

TESTING ACTIVITY: EQUIP. EVAL. BR.

TYPE OF TEST: FLOOR LOAD TEST

1.0 REQUIREMENT: FP 3.14

2.0 PROCEDURE: FP 4.9.6

3.0 RESULTS: No damage was observed after the load was removed.

EQUIPMENT COMPLIED X	TESTED BY USAECOM	TEST COMPLETED 18 JULY 63
EQUIPMENT DID NOT COMPLY	WITNESSED BY M. Deutschman	ISSUE DATE
		Page of pl Appendix

SELRA Form 1008 1 Jan 63 (Replaces ENG Form 1008, which is obsolete.)

Ames-Ft Monmouth, NJ-MON 1614-63

ENCL IV-11-7

EDT DATA SHEET

ITEM UNDER TEST: SHELTER, THINWALL, LIGHTWEIGHT (XE-), SER. NO. ——

PART OF OR USED WITH: ——— (XE-), SER. NO.

IDENTIFICATION: SCL-4366 (5 DEC 61)

TESTING ACTIVITY: EQUIP. EVAL. BR.

TYPE OF TEST: FORDING

1.0 REQUIREMENT: ¶ 3.26

2.0 PROCEDURE: ¶ 4.4.11.5

The fording test was run before and after the Road and R.R. humping tests to determine what effect, if any, the additional environmental tests would have on the watertightness of the shelter. The depth of immersion was changed from 24" to 30" by request of the project engineer.

3.0 RESULTS: The fording test run prior to the Road Tests and R.R. humping test showed that the shelter leaked; approximately 3½ gals. penetrated the shelter in the 30 minutes specified. The fording test run subsequent to the stated environmental tests showed a leakage of 24¼ gals.

EQUIPMENT COMPLIED [ ]	TESTED BY A.P.G.	TEST COMPLETED 12 JULY 63
EQUIPMENT DID NOT COMPLY [X]	WITNESSED BY M. Deutschman	ISSUE DATE
		Page / of of Appendix

SELRA Form 1 Jan 63 1008 (Replaces DA FORM 8644, which may be used until exhausted) Army Fit Monmouth, NJ-MON 112A-63

incl 1

ENCL IV-11-7

EDT DATA SHEET

ITEM UNDER TEST (XE-), SER. NO.
SHELTER, THINWALL, LIGHTWEIGHT
PART OF OR USED WITH (XE-), SER. NO.

IDENTIFICATION
SCL-4366 (5 DEC 61)

TESTING ACTIVITY
EQUIP. EVAL. BR.

TYPE OF TEST
FORDING

1.0 REQUIREMENT: MP 3.26

2.0 PROCEDURE: MP 4.4.11.5

The fording test was run before and after the Road and R.R. bumping tests to determine what effect, if any, the additional environmental tests would have on the watertightness of the shelter. The depth of immersion was changed from 24" to 30" by request of the project engineer.

3.0 RESULTS: The fording test run prior to the Road Tests and R.R. bumping test showed that the shelter leaked; approximately 3 1/2 gals. penetrated the shelter in the 30 minutes specified. The fording test run subsequent to the stated environmental tests showed a leakage of 24 1/4 gals.

EQUIPMENT COMPLIED	TESTED BY A.P.G.	TEST COMPLETED 12 JULY 63
EQUIPMENT DID NOT COMPLY X	WITNESSED BY M. Deutschman	ISSUE DATE
		Page 1 of of Appendix

SELRA Form 1008 (Replaces MMSC-8644, which may be used until exhausted) 1 Jan 63 Signal Corps, Monmouth, NJ-MLIN 152A-63

ENCL IV-11-8

EDT DATA SHEET

ITEM UNDER TEST (XE-), SER. NO.
SHELTER, THINWALL, LIGHTWEIGHT — —

PART OF OR USED WITH (XE-), SER. NO.

IDENTIFICATION
SCL - 4366 (5 DEC 61)

TESTING ACTIVITY EQUIP. EVAL. BR.

TYPE OF TEST TRANSPORTABILITY, VEHICULAR

1.0 REQUIREMENT: MP 3.27.1

2.0. PROCEDURE : MP 4.4.10

3.0 RESULTS : No visible damage was incurred by the shelter after being subjected to the Munson Test Course, Perryman Cross Country Road, and the Churchille Road in turn as stated in the applicable specifications.

EQUIPMENT COMPLIED X	TESTED BY A.P.G.	TEST COMPLETED 10 JULY 63
EQUIPMENT DID NOT COMPLY	WITNESSED BY M. Deutschman	ISSUE DATE
		Page 1 of 1 of Appendix

SELRA Form 1 Jan 63 [illegible] which may be used until exhausted. [illegible] NAVEXOS 1572A-63

ENCL IV-11-9

EDT DATA SHEET

ITEM UNDER TEST: SHELTER, THINWALL, LIGHTWEIGHT (XE-), SER. NO. —

PART OF/OR USED WITH (XE-), SER. NO.

IDENTIFICATION: SCL-4366 (5 DEC 61)

TESTING ACTIVITY: EQUIP. EVAL. BR.

TYPE OF TEST: FLAT DROP

1.0 REQUIREMENT: MP 3.2.2.2

2.0 PROCEDURE: MP 4.4.3 This test was run before and after the rotational drop tests at the request of the project engineer. The purpose of the repeat drop test was to establish a damage pattern.

3.0 RESULTS: (a) The clearance at the top of the large door became more wedge-shaped. The shelter outer skin separated from the edge angle above the skids on both sides of the shelter. The skids became wedged slightly at one end of the shelter.

(b) The weld spots on the rt. side of the door opened up the full height of the shelter. Several weld spots opened on the left side of the door. The rear edge angle joints cracked. The inside of the large door was badly distorted.

EQUIPMENT COMPLIED ☐	TESTED BY USAERDL	TEST COMPLETED 27 JULY 63
EQUIPMENT DID NOT COMPLY X	WITNESSED BY MR Deutschman	ISSUE DATE
		Page 1 of 2 of Appendix

SELRA Form 1 Jan 63 1003 (Replaces MSEL-1089, which may be used until exhausted) Army-Ft Monmouth, NJ-MON 1512-1

E-C-II-4 B

EQP. SHELTER, THINWALL LIGHTWEIGHT	TEST FLAT DROP	DATE 21 JULY 6

CONTINUED

3.0 RESULTS:

The skid ends were jammed against the shelter bottom

The shelter inner and outer skins were torn and buckled in several places.

The load support members were buckled; the damage being visible from the outside of the shelter at the top angle.

ENCL IV-11-10

EDP DATA SHEET

ITEM UNDER TEST (XE) SER. NO.
SHELTER, [illegible] SMALL, LIGHTWEIGHT

PART OF OR USED WITH (XE) SER. NO.

IDENTIFICATION
SCL - 4366 (5 DEC 61)

TESTING ACTIVITY
EQUIP. EVAL. BR.

TYPE OF TEST
ROTATIONAL DROP

1.0 REQUIREMENT: # 3.27.2

2.0 PROCEDURE: # 4.4.4

3.0 RESULTS: With the left side of the shelter impacting on the concrete, two more weld spots opened up on the outer [redacted] skin near the door left side.
No additional damage was done to the shelter when it impacted on the front end or the [redacted] right end.
Impacting on the rear end of the shelter caused four more weld spots to open up on the right side of the door.

EQUIPMENT COMPLIED	TESTED BY USAELRDL	TEST COMPLETED 21 July 63
EQUIPMENT DID NOT COMPLY X	WITNESSED BY M. Deutsch	ISSUE DATE
		Page of of Appendix

SELRA Form [illegible] (Replaces SELRA-RSN, which may be used until exhausted)

A change order to the initial contract was received by the Contracts Department of the Special Products Division in January of 1964. It entailed specification changes and modifications.

On December 12, 1963, a cost and price analysis amendment was submitted as indicated on Enclosure # IV-2-1 .

The Advanced Development Model No. 1 contract and specifications were reviewed and Engineering initiated design changes as agreed upon by Signal Corps and Twin Industries. The changes consisted of:

Solid one-piece skids in place of shock type skids to be 3" wide x 2" high to catch ribs of M-37 Truck.

Overall height extension of 6".

A weight increase to approximately 400 pounds.

Extrusion material could be increased to 1/8" thickness.

Locking mechanism to be within the door handle itself.

Skin material to be 7075-T6.

Core material to be UB 150.

Hat and extrusion material 6061-T6 - 7075-T6.

Gussets under the shelf, providing they missed the wheel wells.

Door height increase.

Step and handles located to curbside wall and close to the corner.

Tests were conducted to evaluate and decide what material would best be suited for fabrication and assembly, and also give the best all-around strength requirement needed. (See Enclosure # IV-2-2 - IV-2-4)

model at Radio Corporation of America, Burlington, [illegible], of March of 1964.

By physical inspection and evaluation, certain changes appeared to be mandatory, such as:

> Sandwich panel construction for additional strength to better withstand solar loads and insert pulls.
>
> Skids be relocated and widened to accommodate the ribs of the M-37 Truck.
>
> Interlock features were required in the roof to decrease potential pull-away or drop of the side member due to rough handling or testing. The interlock features would also tend to increase the overall rigidity of the shelter and distribute shock to the floor and skids.
>
> Gusset reinforcement under the shelf in the event of internal support failure.

With the design changes and previous failures in mind, and the material selected, Twin Industries started procurement, planning and fabrication. Preliminary design prints were completed and released before the end of March, 1964. Fabrication commenced the beginning of April.

A problem encountered during fabrication caused some concern, but was solved with a minimum amount of time lost. The door end extrusions (See Enclosure # IV-2-5) introduced a compression problem. It was necessary to adapt the door extrusion in such a way so as to give maximum weather and EFI seal. This was accomplished by designing a Shur-Loc extrusion which would give an interlock effect. With the two exposed tips depressing deep into the EFI mesh and silicone rubber, therefore expanding the silicone up and around the extrusion, making it weather-tight, the problem was eliminated.

Forming 7075-T6 aluminum stock is very difficult due to constant recurrence of stretch cracks and tears because of the poor forming quality of the material.

The inspection of [illegible] primary concern was quality of the [illegible] accordance with accepted manufacturing procedures.

The door handles and locks originally agreed upon were inadequate for the shelter security and were not sturdy enough for the door locking devices. (See Enclosure # IV-2-6)

The gussets were eliminated in lieu of interior supports. It was Twin Industries' intention to use the gussets only in the event of internal failure of the structural support due to testing.

The handhold located on the roof was put in line with a stiffener plate for added mounting strength.

During the engineering and planning stages of the Advance Procurement Model #1, Twin Industries received an order for four (4) additional S-318 Shelters. These were manufactured and shipped, waiving tests. Because of engineering changes incorporated during the manufacture of these units (#2 - #5) the shelter weight remained at 415 pounds.

Upon completion of the assembled shelter on May 12, 1964, the shelter was forwarded to Bell Aerosystems in Buffalo, New York, for tests on May 15, 1964.

The shelter was scheduled to undergo the following tests:

a. Moisture Resistance
b. Heat Transfer
c. High Temperature Test and Materials
d. Low Temperature
e. Airtightness Test
f. RFI Shielding Test

Moisture Resistance - The shelter was required to be capable of withstanding relative humidity up to 90% for an indefinite period of time and exposure at

[illegible] cycle was performed [illegible] the shelter.

Heat Transfer - The materials used and the design of the shelter was such that the overall coefficient of heat transfer was not to exceed 0.20 BTU per hour, per square foot, per degree Fahrenheit. The test was conducted in an auxiliary insulated 8' x 16' x 10' chamber refrigerated by a 700 cubic foot Bowser temperature altitude chamber. As the test chamber was cooled to -40°F, the power was increased to electrical resistance heat source to obtain the required 100°F minimum temperature differential. No physical signs of deterioration were noted.

High Temperature - The shelter, with doors closed, shall be placed in a chamber with air maintained at 120°F to 125°F. The air shall be recirculated with a velocity not exceeding seven miles per hour in the vicinity of the shelter. After the outside shelter skin has stabilized between 120°F and 125°F, the doors and their hinges and latches shall operate freely. The full solar load shall then be applied to the roof. If the end or side walls are constructed of different composition, type, or density of core material than the roof, each different wall shall also be subjected to the full load simultaneously with the roof or in a separate cycling. The solar load shall be applied as rapidly as possible using at least twenty-eight number 100T3, 250-volt bulbs (as made by G.E., Sylvania, or equal) per panel. The bulbs shall be arranged in four rows of seven bulbs each, or more as required, and shall operate within 10 percent of their rated voltage. The solar load shall be applied a period of four hours after all portions of the outside skin of the panel being tested have reached a temperature of 125°F [illegible]. After completion of the four-hour solar load, the air temperature shall be raised

[illegible] to the rain, [illegible] atmosphere to assure [illegible] above temperature requirements. The above cycle shall be repeated three times. There shall be no core growth, delamination, buckling, or deterioration of structural strength during as a result of the above testing.

The above test was conducted June 6, 1964 and June 7, 1964. The results were satisfactory.

Low Temperature - The closed shelter was subjected to three (3) cycles of low temperatures. The doors, latches and hinges were to operate freely when tested. The shelter was placed in the 700 cubic foot Bowser temperature chamber. The test was conducted with thirty (30) thermocouples installed on the shelter and ten (10) installed to measure air temperature inside the shelter. There was no damage in core material and no delaminations, buckling or deterioration of the structural strength of the shelter as a result of this test.

Airtightness - The shelter was airtight to the extent a residual air pressure of not less than 3/4 inch of H2O remained in the shelter four (4) minutes after initial air pressure of 1-1/2 inches of water had been developed therein, with the door closed, and without the use of additional sealing devices. The shelter was placed in the 700 cubic foot Bowser temperature chamber.

RFI Shielding Test - This test was conducted at a later date when the shelter was repaired and re-submitted for further tests.

Upon completion of the test schedule at Bell Aerosystems, the shelter was returned to Twin Industries for additional test requirements which were scheduled as follows:

Simulated Payload - Installation of test weights to simulate a payload condition. The weights were distributed over an area within the shelter to equal a 1200 pound payload as indicated on Enclosure # IV-2-7 .

Munson Road Test - The shelter was subjected to the following road test conducted at Twin Industries Test Course. The shelter mounted on a truck, 3/4 ton, 4 x 4, Series M-37, was transported ten (10) times over the following sections of the Munson test course in the following order and at the indicated speeds:

a.	Course Washboard (6" waves spaced 6' apart)	5 mph
b.	Belgian Block	20 mph
c.	Radial Washboard (2" - 4" waves)	15 MPH
d.	Spaced Bumps (4" - 6" waves)	20 mph
e.	Any Short Sections between the Above	20 mph

The tests were run at 5, 10, 15 and 20 mph; ten (10) laps each at each of the indicated speeds. One (1) lap is defined as traversing the course in both directions.

The shelter was checked four (4) times during the test. Two (2) small delaminations developed; one in the front wall near the floor riser curbside corner and one running along floor riser curbside in the rear panel.

Railroad Bump Test - The shelter was loaded in a manner normally used for shipment on a railroad flat car. The test was conducted on a flat stretch of track. A 165,000 pound car traveling at 9 mph was impacted. The test car coupled to two other cars. These cars were stationary with the brakes off. Four (4) impacts were performed; two (2) with the shelter positioned longitudinally to the flat car and two (2) positioned laterally. The direction of each impact was selected by the Government. No buckling or tie-down which held the shelter

in place were torn loose by the impact, the test was to be repeated. The result of the impacts is as follows:

a. Impact #1 - 10.3 mph - Front
No visible damage to the shelter.

b. Impact #2 - 8.6 mph - Rear
Delamination of the inside skin rear panel between door frame and roadside wall was noted.

c. Impact #3 - 9.7 mph - Curbside
Two (2) of the four (4) tiedown assemblies broke during impact due to failure of bolt in turnbuckle assembly, one of which cut a 1-1/4" tear through the outside skin of the curbside panel. The weld joint of the lower curbside door frame corner cracked, causing an approximate .125 separation at the corner and buckling of the outside skin of the rear end panel. Two (2) broken spotwelds in the area of the lower door hinge previously reported as loose, increased considerably. Small cracks appeared in welded corner joints.

d. Impact #4 - 8.5 mph - Roadside
No further damage was noted to the shelter as a result of this impact.

After careful evaluation, it was decided that the damage which occurred during the second and third railroad impact could be attributed to unsatisfactory welding and that the failure of the lower door frame to absorb the load caused considerable damge to the rear panel.

The addition of a reinforcement to strengthen the door frame was necessary before re-testing of the shelter. The fix involved refastening the inner skin with rivets in the area of the fix.

e. Impact #5 - 8.5 mph - Roadside
Inspection of the shelter showed no further damage to the shelter as a result of the test.

f. Impact #6 - 7.8 mph - Curbside
This impact had to be re-run because the speed was considered to be too slow.

g. Impact #7 - 8.5 mph - Curbside
Inspection of the shelter showed no further damage to the shelter as a result of the test.

Sling Drop Test - The shelter was suspended approximately 1/2 inch from the ground by means of the lifting sling assembly at its fully extended height. The

sling assembly and shelter were dropped in freefall so that the assembly strikes the roof of the shelter. The test was repeated five (5) times with no visible damage to the roof of the shelter other than sling indentations.

Skid Bearing Test - The shelter was balanced on a two-inch pipe along the full length of the skid. No damage was noted as a result of the test.

Three-Point Support - Para. 4.3.3.5. The shelter was supported on three (3) corners by 6 x 6 wood blocks. The doors opened and closed freely while shelter was supported in position.

Flat Drop - Para. 4.3.3.6. The shelter was raised eighteen (18) inches above a concrete pad (measured from the bottom of the skid) and allowed to fall freely with skids impacting into the concrete. There was no damage as a result of the test.

Rotational Drop - Para. 4.3.3.7. The shelter was placed on a hard concrete pad with a 4 x 4 inch member along one edge under the skid. The opposite edge was raised to a height of eighteen (18) inches (as measured from the bottom of the skid) and allowed to fall freely onto the concrete. The test was performed once on each bottom edge for a total of four (4) drops. There was no damage as a result of this test.

Towing - Para. 4.3.3.8. The shelter was towed for a minimum of 1400 feet in each direction (front & rear) on the skids at a speed of five (5) miles per hour over rough terrain. As a part of the towing test, four (4) right angle turns were made; the turns were made with the initial position of the longitudinal axis of the shelter perpendicular to the truck, and the towing eye of the truck directly in line with the leading edge of the shelter. The pull was made on

one (1) towing eye of the shelter, with no damage to the shelter as a result of the test.

Lifting - The shelter with an additional 2600 pounds to the 1200 pound load, uniformally distributed over the floor, was suspended by the four (4) lifting eyes for a period of thirty (30) minutes. There was no undue distortion or damage to the shelter as a result of this test.

Deep Fording - This test was started and stopped because of excessive leakage around the door gasket due to our inability to adjust the required compressability between the rubber and RF gaskets.

At this point, Twin Industries was instructed by the Contracting Officer's Technical Representative, in a letter, (See Enclosure # IV-2-8) to stop tests on the model and incorporate a new door end panel that included all requested design changes, then re-test the shelter to specified tests.

As directed by the letter from the Contracting Officer, all tests were stopped. The shelter rear wall was removed. A new wall was fabricated and installed. The raw edge around the inner door frame was riveted. This course of action was taken in order to eliminate delamination initiated in that area. Hat section structurals were added between shelf and door. Doubler plate was added on hinge side of the door.

After assembly of the wall section, the completed shelter was re-scheduled for re-test in the order submitted by the Signal Corps Agency as indicated on Enclosure # IV-2-8 . Two (2) delaminations existed inside the shelter before resuming the tests, but did not enlarge during the test.

Water Tightness Test - The surface of the shelter was sprayed with water from nozzles (Model 6298Q) manufactured by Spraying System Co., Bellwood,

Illinois) or equal. The nozzles operated at forty (40) pounds per square inch. Dynamic pressure measured adjacent to the nozzles, were approximately nineteen inches (19") from the shelter, and pointed directly at the shelter panel under test, and located in a pattern to provide uniform coverage of the panel under test. Nine (9) nozzles were used for each end panel and for each side or roof panel. All five (5) exposed panels were tested for forty (40) minutes each. More than one panel may be tested at a time if so desired, and Twin Industries took advantage of this exception and tested all panels at one time. No additional caulking, taping, etc. was used during this test. The shelter was dry and indicated no evidence of leakage as a result of this test.

Deep Fording - The shelter, secured by its tiedowns to a suitable platform serving as the sinking device, was submerged for a period of one (1) hour in water to a depth of thirty (30) inches above the bottom of the skids. No special fording kits, or additional caulking, taping, etc. was used in the performance of the test. The shelter was dry and indicated no evidence of leakage as a result of the test.

Vehicular Transport - The shelter was mounted on a 3/4 ton 4 x 4 M-37 Truck and was transported over a 350 foot approved obstacle course. The tests were run at 5 mph, 10 mph, 15 mph and 20 mph. Ten (10) laps were completed at each separate speed. (One lap is defined as traversing the course in both directions). The shelter showed no evidence of damage as a result of this test.

Railroad Transport - The conditions of the re-test were identical to the previous. The following is the results:

Impact #1 - Door End - 9.37 mph
The upper enclosure angles wrinkled just forward of the castings

both road and curb sides. This was believed to be due to the shortening of the lifting eye castings which have been lengthened since the test.

Buckled outside skin slightly in the area between legs of the hat section running along shelf area, on the door end panel running both sides of the door.

Outside skin broke loose at edge of door jam approximately 2.0 due to two (2) rivets missing in this area.

Impact #2 - Curbside - 11.16 mph

Engineer failed to stop locomotive in time, whereby engine and loaded gondola car impacted test car with shelter aboard at 11.16 mph. The total impact weight was 405,300 pounds.

Inside skin along door jam broke loose in a small area. There was no further damage as a result of Impact #2.

Impact #3 - Roadside - 8.63 mph

There was no further damage as a result of Impact #3.

Flat Drop Test - The same conditions and requirements were met as in the previous flat drop test. The shelter showed no evidence of damage as a result of the test.

Rotational Drop - The same conditions and requirements were met as in the previous rotational drop test. The shelter showed no evidence of damage as a result of the test.

Water Tightness Test - The shelter was placed in the rain chamber for a period of sixty (60) minutes as in the first previous test. At the completion of the test, approximately two (2) ounces of water was noted on the floor of the shelter near the door opening. The remaining surface of the shelter remained dry throughout the test.

Deep Fording Test - The shelter was returned to the deep fording tank for sixty (60) minutes as in the first previous test. At the completion of this test, the inside of the shelter remained dry.

Shielding - The shelter was to be designed to provide an attenuation of at least 60db to electric and magnetic fields and to plane waves in the frequency range from 0.15 to 10,000 MC with the doors closed.

The shelter initially failed the RFI tests because silicone rubber adhesive was discovered between the monel mesh and the aluminum extrusion; therefore, insulating the required conductive contact for proper RFI. In the final tests, the gasket was removed and the adhesive cleaned out. Steel wool (which cannot be used as a gasket) was used only to demonstrate that if a satisfactory RFI gasket material and applications had been applied, the shelter probably would have passed the test.

The Advanced Development Model #1, after repairs and retesting, weighed 442 pounds. This increase can be attributed to the replacement of the new door end panel. Additional adhesive and sealer was used in manufacturing and assembly of the wall.

With the test completion and final acceptance of the S-318 Shelter, preparations were made for shipment in accordance with an acceptable mode of transportation.

Engineering proceeded to up-date for final release, the drawing affected by changes resulting from testing and re-testing. The new changes which resulted from failure through testing were incorporated into the new door end panel.

To strengthen load bearing capacity of the main door, a back-up strip of aluminum was incorporated behind the hinge.

A hat section structural was added to the door end wall between the door frame and outer walls, thus decreasing shifting moment of the shelf portion of the shelter.

The door handles were changed to a heavier type handle which incorporates an outer lock with an emergency release hasp operable from the inside of the shelter. The hasp was used on the auxiliary door only. There was no requirement for a hasp on the main door because, in the event the shelter was loaded aboard a truck with the tailgate up, the door even though unlocked, could not be opened. The use of an outside heavy duty lock was intended to discourage breaking and entering of the shelter by picking the lock which previously had been incorporated in the door handle.

The exposed edge of the inner skin around the periphery of the door was riveted to insure decrease of delaminations caused by rough handling.

With the incorporation of all engineering changes in design, a complete set of reproducible drawings were reviewed, checked and re-submitted to Twin Industries for incorporation of changes to the originals. The drawings were revised in accordance to the marked prints and re-submitted to Signal Corps Agency as final.

In September, 1964, the completed shelter was shipped to Clifton, New Jersey, for further development with equipment installation.

ENCL IV 2-1

File WC copy

December 12, 1963

U. S. Army Materiel Supply Agency
Fort Monmouth Procurement Office
Fort Monmouth, New Jersey

Attention: Mr. Frank Cavaliere, Contract Specialist
SELMA/FMB 1b2R

Subject: Order #00120-PM-62-91
Contract DA-36-039-SC-90814

Reference: Amendment to Item #4

Gentlemen:

In conjunction with meetings and discussions held at your facility with our Mr. Daiber, we wish to submit our cost and price analysis supplying an Advanced Engineering Model per SCL-4366B and is restricted to Item #4 only. All other items of this contract remain as is.

Labor:					
	Fabrication	420 hrs.	@ $1.93	$ 810.60	
	Inspection	25 hrs.		48.25	
					$ 858.85
	Overhead				1,228.16
	Material				904.02
Engineering:					
	Design	360 hrs.	@ $3.49	$ 1,256.40	
	Drafting	480 hrs.		1,675.20	
					2,931.60
	Overhead		@ 60%		1,758.96
	Material				125.00
Shipping Preparation					35.00
Freight Cost					33.70
Tool Maintenance					42.00
Tooling					500.00
	Sub-Total				$ 8,417.20
G & A			@ 4.5%		378.78
	TOTAL COST				$ 8,796.07

ENCL IX 2-1

Total Cost		$ 8,796.07
Profit	@ 10%	879.61
	SELLING PRICE LESS TESTING	$ 9,675.68
Testing Cost		17,522.29
TOTAL SELLING PRICE (Item #4)		$27,197.97

It must be noted that above testing cost has been reduced by $4,300 from previous verbal quote due to the receipt of a firm quote for the Munson Road Test from Aberdeen Proving Grounds.

As also discussed, please find an alternate proposal offering a simulated Munson Road Test as available at our ffacility for a nominal amount. This alternate proposal further decreases the cost to the Government of an additional $3,000.00 in the high and low temperature tests.

Where originally it was our intention to perform the Solar Load Test in six (6) cycles and Low Temperature Tests to Mil Std 169 in three (3) cycles (steps 5 through 10), we are now going to perform the Solar Load Test in three (3) cycles and Low Temperature Tests as stated above.

Total dollar value of our alternate proposal would be as follows:

Selling Price Less Testing	$ 9,675.68
Alternate Testing Cost	13,311.22
Total Selling Price (Item #4)	$ 22,986.90

If our alternate proposal is acceptable and Twin Industries is to perform the Munson Road Test at this facility, a Government Furnish Truck is required.

Thank you for your patience in this matter.

Very truly yours,

Peter A. LaCesa

Peter A. LaCesa
Contracts Manager
SPECIAL PRODUCTS DIVISION

PAL/mar
CS-12-25-63

bcc: Messrs. E. M. Daiber
J. L. Hesburgh (Mrs.)
John J. Lee
E. Summers
M. Scalise

TCB-QC-26

TWIN COACH COMPANY
AIRCRAFT MISSILES

ENCL. IV 2-2

REQUEST FOR LABORATORY SERVICE

Report No. _____

Vendor _____ Material 5086-H-34 Date 3-13-64

P.O. No. _____ Batch No. _____ Spec. No. SCL-4366 B

R.R. No. _____ Quantity Received 3 samples Vendor Cert. Rec'd. ☐ yes ☐ no

Contract _____

Object of Test: Skin Evaluation Test, Spotweld

Requested by: BRM Dept. Eng Storage Requirements _____

TEST REPORT

Date _____
No. hours Req'd _____

Results: Diameter of nugget .125
Diameter of spot .187

Samples	.020 x .016	.016 x .016	.020 x .020
①	300	250	350
②	275	260	375
③	275	250	375
Average	283	253	367

Penetration between 70 & 80%

Recommendations:

Penetration is difficult to evaluate with a metal up using .016 & .020 mat'l. A 7X TO 10X magnifying glass is advisable to have better control.

Tested by W. Gallardo Jr. Approved by E. Bumsley

To: Retest Date _____

TCB-QC-26

TWIN COACH COMPANY
AIRCRAFT MISSILES

ENCL IV 2-2

REQUEST FOR LABORATORY SERVICE

Report No. _____

Vendor _____ Material 61ST6-.016 6061-T6.020 Date 3-24-64

P.O. No. _____ Batch No. _____ Spec. No. SCI-4366-B

R.R. No. _____ Quantity Received 9 samples Vendor Cert. Rec'd. ☐ yes ☐ no

Contract _____

Object of Test: Skin Evaluation Test, Spotweld

Requested by: J.C.R.M. Dept. Eng. Storage Requirements _____

TEST REPORT

Date _____

No. hours Req'd _____

Dia. of nugget

Dia. of spot

Results:

Samples	6061-T6 .020 61ST6-.016 .020x.016	61-ST6 .016x.016	6061-T6 .020x.020
(1)	250	200	275
(2)	240	220	275
(3)	250	210	275
Average	247	210	275

Recommendations: Penetration between 75% & 80%

Penetration is difficult to evaluate with a naked eye using .016x.020 mat. A 7x to 10x magnifying glass is advisable to have better control.

Tested by L.C. Phillips Approved by _____

To: Retest Date _____

CB-QC-26

TWIN COACH COMPANY
AIRCRAFT MISSILES

ENCL. IV 2-2

REQUEST FOR LABORATORY SERVICE

Report No. _____

Vendor _____ Material 5052-H34 .020 5052-H32 .020 Date 3-24-64

P.O. No. _____ Batch No. _____ Spec. No. SCL-4366B

R.R. No. _____ Quantity Received 9 samples Vendor Cert. Rec'd. ☐ yes ☐ no

Contract _____

Object of Test:

Stir Evaluation Heat, Spotweld

Requested by: BKM Dept. Eng Storage Requirements _____

TEST REPORT

Date _____

No. hours Req'd _____

Dia of nugget
Dia of spot

Results:

Samples	5052-H32 5052-H34 .020x.020	5052-H32 .020x.020	5052-H34 .020x.020
(1)	350	275	340
(2)	340	310	340
(3)	350	300	340
Average	333	295	340

Recommendations: Penetration between 25% - 80%

Penetration is difficult to evaluate with a naked eye using .020 mat. A 7x to 10x magnifying glass is advisable to have better control

Tested by [signature] Approved by _____

To: Retest Date _____

TCB-QC-26

TWIN COACH COMPANY
AIRCRAFT MISSILES

ENCL IV 2-2

REQUEST FOR LABORATORY SERVICE

Report No._____

Vendor_____ Material 7075-T6 Date 2-13-62

P.O. No._____ Batch No._____ Spec. No. SCL-8266B

R.R. No._____ Quantity Received 3 samples Vendor Cert. Rec'd. ☐ yes ☐ no

Contract_____

Object of Test:

Skin Evaluation Test, Spotweld

Requested by: BRM Dept. Eng Storage Requirements_____

TEST REPORT

Date_____
No. hours Req'd_____

Diameter of nugget .125
Diameter of spot .187

Results:

Samples	.020x.016	.016x.016	.020x.020
①	300	260	350
②	300	275	375
③	300	275	350
Average	300	267	358

Recommendations: Penetration between 70 & 80%

Penetration is difficult to evaluate visually & metallographically using .016 & .020 mat'l. A 7x to 10x magnifying glass is advisable to have better control

Tested by E. Gallardo Jr. Approved by E. Bennett

Retest Date_____

To:

5

CB-QC-26

TWIN COACH COMPANY
AIRCRAFT MISSILES

ENCL IV 2-3

REQUEST FOR LABORATORY SERVICE

Vendor _____ Material .020 6061-T6 1/8" Bare Report No. _____

P.O. No. _____ Batch No. V3-MI-527 P73 Date 3-19-62

R.R. No. _____ Quantity Received 3 samples Spec. No. Sol-9366 B Rev. F, 1, 2

Contract _____ Vendor Cert. Rec'd. ☐ yes ☐ no

Object of Test: Skin-Thermal Barrier-Adhesive Test

Requested by: B.R.M. Dept. Eng. Storage Requirements _____

TEST REPORT

Date _____

1" x 1/2" overlap. No. hours Req'd _____

Results:

Samples

(1) 700

(2) 700 Average 700

(3) 700

Recommendations:

Tested by G. Pallanti Approved by _____

To:

Retest Date _____

JB-QC-26

TWIN COACH COMPANY
AIRCRAFT MISSILES

ENCL IV 2-3

REQUEST FOR LABORATORY SERVICE

Report No. _____

Vendor _____ Material .020 SD52-H34 1/8" Birch Date 3-19-64

P.O. No. _____ Batch No. V3-ML-527 P-73 Spec. No. SCL-1366B MMA. 2.1.2.

R.R. No. _____ Quantity Received 3 samples Vendor Cert. Rec'd. ☐ yes ☐ no

Contract _____

Object of Test:

Skin - Thermal Barrier - Adhesive Test

Requested by: BRM Dept. Eng. Storage Requirements _____

TEST REPORT

Date 3-19-64
No. hours Req'd _____

1" x 1½" overlap

Results:

Samples

(1) 775
(2) 750 Average 741
(3) 700

Recommendations:

Tested by _____ Approved by _____

To:

Retest Date _____

TCB-QC-26

TWIN COACH COMPANY
AIRCRAFT MISSILES

ENCL IV 2-4

REQUEST FOR LABORATORY SERVICE

Report No.

Vendor ______ Material 7075-T6 Date 3-12-62

P.O. No. ______ Batch No. ______ Spec. No. SCL-4366B PARA. 4.1.3.

R.R. No. ______ Quantity Received 2 samples Vendor Cert. Rec'd. ☐ yes ☐ no

Contract ______

Object of Test: Skin Evaluation - Impact

Core Mat. NB-150 1/4" wall   Skin Mat. .020 outside .016 inside

Requested by: B.R.M. Dept. Eng   Storage Requirements ______

Cure Time Started 5:00 PM. 3-11-62

TEST REPORT

Date ______
No. hours Req'd ______

Results:

.020 - SKIN BUCKELED AT POINT OF IMPACT BUT DID NOT FRACTURE - SLIGHT DEFORMATION OF THE .016 SKIN CAUSED BY LACK OF SUPPORT AROUND THE OUTSIDE EDGES OF TEST SPECIMEN

(TEST CONDUCTED UNDER SAME CONDITIONS AS CALLED OUT FOR S141 AND S280 SHELTERS)

Recommendations:

Tested by Chas McQuinton Approved by E. Bunnelly

Retest Date ______

To:

TCB-QC-26

THIN COACH COMPANY
AIRCRAFT MISSILES

ENCL IV 2-4

REQUEST FOR LABORATORY SERVICE

Report No._____

Vendor_____ Material 5086-H34 Date 3-12-64

P.O. No._____ Batch No._____ Spec. No. SCL 4366 B PARA. 4.1.3

R.R. No._____ Quantity Received 3 SAMPLES Vendor Cert. Rec'd. ☐ yes ☐ no

Contract THIN-WALL 00120-P62-91-91

Object of Test: SKIN EVALUATION IMPACT

CORE MATERIAL NB-1.50 SKIN MATERIAL .020 OUTSIDE .016 INSIDE

1¼" WALL

Requested by: B.R.M Dept. ENG. Storage Requirements —

CURE TIME STARTED 5:00PM 3-18-64

TEST REPORT

Date_____

No. hours Req'd_____

Results:

THE .020 SKIN FRACTURED AT POINT OF IMPACT - SINKING INTO THE CORE MATERIAL DEEP ENOUGH TO CAUSE DEFORMATION OF THE .016 ON THE OPPOSITE SIDE -

TEST CONDUCTED UNDER SAME CONDITIONS AS CALLED OUT FOR 8141-5200 SHELTERS

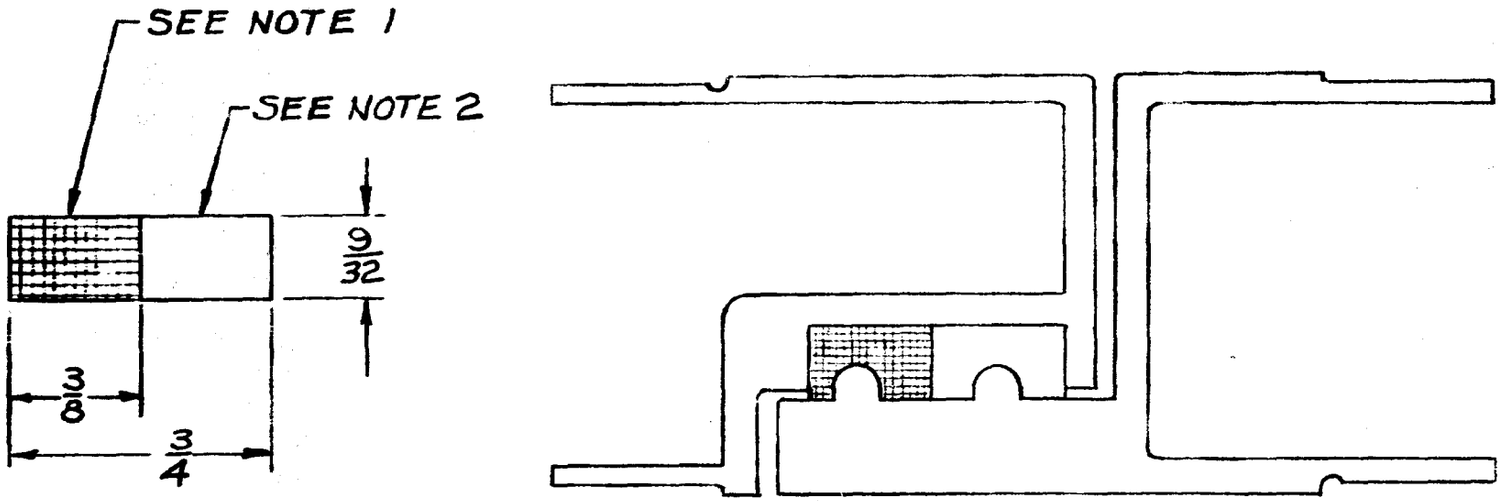
Recommendations:

Tested by Chas. McQuarrie Approved by E. Bramlage

To:

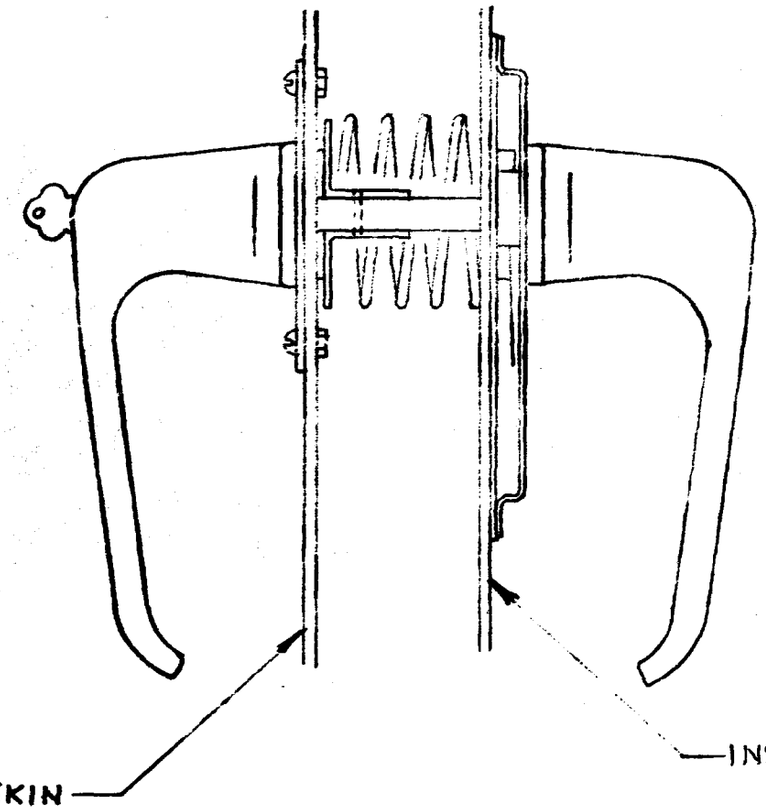
Retest Date_____

ENCL. IV 2-5



NOTES:

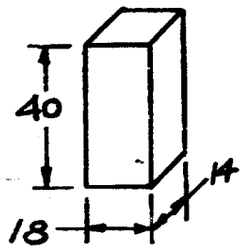
1. R.F.I. SHEILDING TO PROTRUDE AT LEAST 1/16 FROM RUBBER – A MINIMUM AMOUNT OF RUBBER TO BE USED SO AS TO REDUCE THE CHANCE OF ISOLATED INSULATION.
2. PLAIN RUBBER.



ENCL. IV 2-6

DOOR HANDLE ASSY

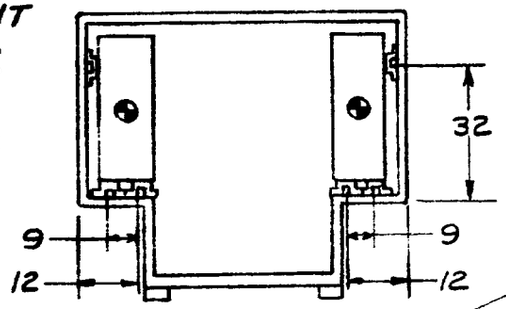
ENCL. IV 2-7



SIMULATED EQUIPMENT LOAD TO BE USED FOR TEST PURPOSES

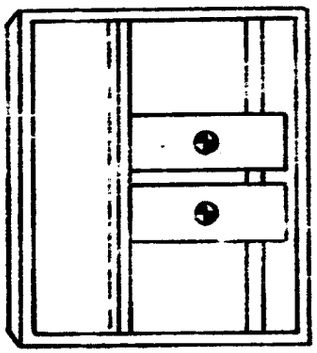
① C.G AT GEOMETRIC CENTER

② EACH TEST LOAD TO BE 300 LBS.

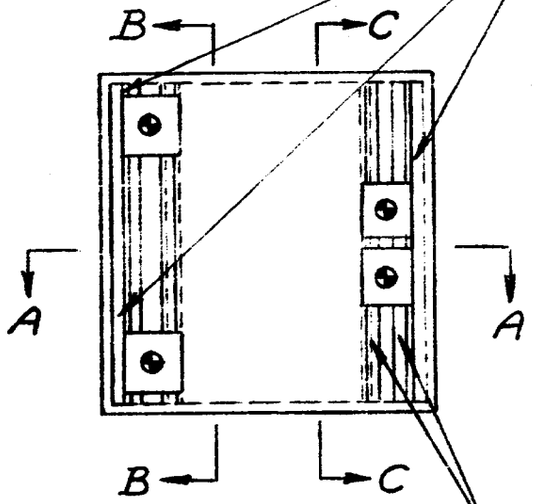


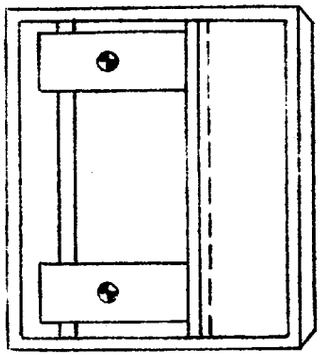
VIEW A-A

HAT SECTIONS BRIDGING ACROSS ADJACENT WALL MEMBERS FOR ATTACHMENT OF TEST LOADS ATTACH TO WALL MEMBERS WITH 5/16" STEEL RIVNUTS



VIEW C-C





VIEW B-B

HAT SECTIONS BRIDGING ACROSS ADJACENT SHELF MEMBERS FOR ATTACHMENT OF TEST LOADS

ENCL IV 2-8 cc M. Ripepi
B. Margiewicz
E. Bernsdorfer

HEADQUARTERS
UNITED STATES ARMY ELECTRONICS COMMAND
UNITED STATES ARMY ELECTRONICS LABORATORIES
FORT MONMOUTH, NEW JERSEY 07703

IN REPLY REFER TO:
AMSEL-RD -GDO
5635 12 977 06

8 - JUL 1964

RECEIVED
JUL - 9 1964
P. A. LaCESA
CONTRACT MANAGER
SPECIAL PRODUCTS DIVISION

The Wheelabrator Corporation
P. O. Box 68
Sayre, Pennsylvania

Attention: Mr. LaCesa, Contracts Manager

Gentlemen:

These Laboratories have reviewed the progress of the acceptance tests of Shelter, Electrical Equipment S-318( )/G being developed by your company under Contract DA36-039 SC-90814.

It is the opinion of these Laboratories that the shelter does not meet the requirements of Specification SCL-4366B in that:

a. During the vehicular transport test the inner skin of the door-end panel delaminated above the shelf on the curbside.

b. During the railroad transport test the welds at the top and bottom of both wall members adjacent to the door cracked, and the lower end of the curbside member was considerably displaced from its original location.

The fix which was subsequently made to the damaged wall members appeared to have corrected the mechanical deficiency. However, the patched shelter no longer meets the specification requirements in that rivets were employed to refasten the inner skin in the vicinity of the fix. Therefore in view of the fact that the wall members adjacent to the door could not be properly welded and since we have no assurance that the bonded but unriveted panel would pass the tests, we must ask that the shelter be retested in its final design state.

You are therefore instructed to:

a. Stop tests on the model submitted.

ENGINEERING
RECEIVED
JUL 13 1964

b. Provide a shelter with a door-end panel [illegible] all changes which are planned to be part of the final design of the shelter, including

ENCL. IV 2-8

AMSEL-RD-GDO
5635 12 977 06
Contract DA36-039 SC-90814

8 - JUL 1964

weight reduction items. In so doing you are authorized to employ mechanical fasteners on the inner skin raw edges of the doors only.

c. Conduct the following tests on the shelter in the order given:

(1) Watertightness (paragraph 4.3.2.2)
(2) Deep Fording (paragraph 4.3.3.10)
(3) Vehicular Transport (paragraph 4.3.3.1)
(4) Railroad Transport (paragraph 4.3.3.2)
(5) Flat Drop (paragraph 4.3.3.6)
(6) Rotational Drops (paragraph 4.3.3.7)
(7) Watertightness (paragraph 4.3.2.2)
(8) Deep Fording (paragraph 4.3.3.10)
(9) Shielding Effectiveness (paragraph 4.3.6)

Finally, you are requested to inform the Contracting Officer as to the estimated completion date of the above and to keep these Laboratories informed as to the progress of the a bove and as to the scheduling of the above tests.

This letter shall not be construed as authorizing a change in contract price, quantity, quality, or delivery schedule.

Very truly yours,

CA Zelaites

CHARLES A. ZELAITES
Contracting Officer's
Technical Representative

V. CONCLUSIONS

The advent of the S-318 Shelter was well received as a challenge with no immediate area of serious problems.

The intent of the engineers responsible for development was mainly two-fold:

Weight - To be compact in size and weigh as little as design would allow.

Strength - Dependent upon weight to supply as much strength in the critical usable area as design would allow.

The skids proved to be a major problem and investigation of material and shock function design was laborious. Using circular elastomers designed for special shock loading made height requirement more than the requirement would allow. During actual test, evidence of bottoming and jamming of skid encasement posed additional problems before attempting a production run. The recommendation to remain with a solid type skid proved to be an immediate answer to additional design time that would be required for extensive investigation of shock skids.

The initial weight requirement was 300 pounds, but was progressively increased to 430 pounds. Throughout the manufacture and assembly of the component parts of the shelter, material weight accummulation was next to impossible to control. Adhesive, sealer and paint applications were proven to be the most difficult to control. Added splices and back-up strips necessary for the strength requirement also added to the overall weight. The final S-318 Shelter does not exceed 415 pounds, as previously stated. Additional structures and/or modifications can be incorporated without appreciable weight increase over the 430 pound requirement.

With the manufacture and assembly of five (5) S-318 Shelters, Twin Industries' knowledge of fabrication and assembly increased. Each shelter reflected excellent workmanship and conformance to acceptable manufacturing procedures.

Wall members offered adequate support, but spot welding was not acceptable and proof of this was established during railroad tests. Through testing of various materials and spots, more shear and tensile loads were established. In order to maintain this desired effect, rigid inspection was imposed on the line to insure that spot welders maintained their equipment and standard for better spot control.

RFI applications were carefully analyzed and production procedures established to insure excellent shielding be guaranteed. RFI shielding of shelters had reached a point where it became imparative to control the amount of leakage into and out of an enclosure. Many new and valued tips on effective shielding was established after the initial tests. Itemized procedures have, and still are, being investigated to instruct and control applications of shielding on a production basis.

Material selection became troublesome due to the fact that almost every specimen tested resulted in either greater shear or tensile, but never both at the same time. These variations hampered designability. Conformity and interchangeability to the extent of covering all critically loaded areas properly with one type of material, was the foremost thought throughout production.

VI. IDENTIFICATION OF PERSONNEL

Personnel associated with the Thinwall Lightweight Shelter Project currently identified as the S-318()/G Field and Mobile Shelter:

William E. Ciccarelli - Chief Engineer
Twin Industries Corp. at Buffalo, N. Y.
February 196[illegible] - June 1962

Robert F. Geiger - Director of Engineering
Twin Industries Corp. at Buffalo, N. Y.
June 1962 - June 1963

Donald J. Cline - Chief Engineer
Twin Industries Corp. at Buffalo, N. Y.
June 1962 - November 1962

Frank Lakowitz - Project Engineer
Twin Industries Corp. at Buffalo, N. Y.
August 1962 - June 1963

Michael E. Daiber - Engineering Manager
Twin Industries Corp., Special
Products Division, Sayre, Penna.
June 1963 - January 1964

James Woodend - Engineering Manager
Twin Industries Corp., Special
Products Division, Sayre, Penna.
January 1964 - Present

Edmund R. Moore - Engineer
Twin Industries Corp., Special
Products Division, Sayre, Penna.
January 1964 - Present

Benjamin Margerum - Engineer
Twin Industries Corp., Special
Products Division, Sayre, Penna.
January 1964 - May 1964

VII. OVERALL CONCLUSIONS

Engineering, upon receipt of the initial order, carefully investigated all areas surrounding the design, selection of material and fabrication. Due to this shelter being the first of its kind and as an eventual replacement for the S-153 and S-144 Shelters, it was the intent of the Engineering Department to produce a design which would be capable of meeting all standards and tests required of this new design.

The problems that resulted from one point of work to another were dealt with to achieve the best possible solution, from a labor standpoint as well as time standpoint. Constant supervision of the Engineering Department enabled other departments to coordinate more freely to accomplish the required results. The only lost part of the first shelter was witnessing the final test results.

By the time the contract was transferred to Sayre, the knowledge gained from the first Development Model was of great value. The questionable areas resulting from the tests of the first shelter were revised extensively to meet the rigid test requirements set forth.

Through close coordination with Engineering, Quality Control became more involved regarding the tests and acceptance. After witnessing the tests and their results, Engineering then became more familiar with specific problem areas such as the door end failure and RFI application and were able to satisfactorily re-design and eliminate future failure of these areas.

Quality Control, through the initial manufacturing and assembly of the first S-318, established a great deal of information that would reflect on all future units. Although Quality Control was not represented for the tests of the S-318,

they did maintain a high standard of quality on all parts manufactured, fabricated, purchased and assembled.

When Quality Control assumed responsibility for testing of the shelter, no details or effort was spared to insure the shelter would meet the design requirements. All test data was, and still is, being evaluated for additional improvement to the shelter for future procurements.

With the completion of the contract evaluations on tests, manufacturing procedures, coordination between service departments and Quality Control were analyzed and revised to include more flexibility and smoother activity flow.

It is evident with the accomplishment of the S-318 Shelter design and revised company procedures, the capabilities of Twin Industries as a shelter manufacturer are second to none.

VIII. RECOMMENDATIONS

The unstable properties of 7075-T6 aluminum sheets are erratic and difficult to work due to the thin gage of the material. Spot welding must be closely supervised in order to control for burn, adhesion, nugget areas, and the walking of material as welding progresses. Going to a slightly larger spot granted an additional 40 psi which can be appreciated in this type of structure. Closer inspection of the welding of the door frame, jam, floor and shelf framework, to insure proper penetration of all welds, leaving weld bead on the part, where possible, rather than grinding, would add a small amount to the total weight of the shelter, but the end result would be an increase in strength.

Because of the design and shape of the door and jam extrusions, silicone bronze or some other agent should be used to dissipate intense heat during welding to reduce creepage and warpage of the frames.

Material 7075-T6 forming qualities are not ideal. Forming on this material is difficult and extreme caution and care is recommended to avoid stretch cracks and tears due to poor elongation and forming qualities. Rigid inspection is important in order to maintain a high degree of quality.

Application procedures and Quality Control standards should be initiated prior to fabrication regarding proper shielding methods. When using VX seam caulking compound, which is applied by a spatula, consistency is hard to maintain. VY caulking compound is equivalent to VX, but has the capabilities of being applied through a tube by hand or air pressure, thus tending to give density consistency for better shielding properties. Application procedures should

include correct application of RFI duo-gasketing. The gasket should be previously coated with an adhesive rather than applying adhesive at installation. By doing this, it would not be so easy to run adhesive onto the mesh part of the gasket, therefore, breaking continuity, between surfaces.

A more flexible specification should be initiated to elaborate on the different frequency spectrums involved in testing. MIL-STD-285 is the only suitable applicable specification available, but its primary use is for screening room in which there is a decisive difference in materials and their shielding properties as compared to a shelter.

Incorporation of a more suitable gasket mesh for shielding is desirable. Monel is fine in a medium frequency range, but would not be able to pass a .14KC or 1KMC requirement without extensive alteration to the shelter. Tin is very fine but does not have the corrosion resistane qualities of monel.

Resistance seam welding is recommended on attachment of outside skin edges to the extrusions. This would reduce minute cracks which are areaway for frequencies to escape into or out of.

Lifting casting length increase which would add another structural pick-up point would increase the overall strength of the shelter.

With the revision of core material, it is recommended that HD300 series from Dow Chemical be used in place of Zerocell. This newly developed core material has a 2 to 5 pound density; average of 3.3.pound density. It can maintain a minimum of 200 psi.

To insure proper squareness and flatness, bonded panels require that:

1. Skins must be flat; dents, wrinkles, bulges and oil cans must not be tolerated.

2. Internal details, such as foam core structural members and insulating strips, must be of matching uniform thickness.

3. Foam core must fill their respective areas completely. If not, adhesive will, thus increasing the overall weight.

4. Adhesive must be applied only to the bonding areas in uniform film of even thickness.

5. Flat, rigid overlay plates must be used when bonding, in order to cover the entire surface which is being bonded. Step structures, such as the shelf and floor assembly, require a rigid and accurate form to nest outer skins.

6. Braces should be used when framing door, windows, access panel, and openings.

7. Bonding pressure must be applied evenly over the entire area of overlay plates.

Metalizing through flame spray may be an answer to increased RFI control. Shielding effectiveness, as well as weight, application methods, and cost estimates, are currently under investigation.

A more suitable method of bonding the foam into the horizontal hat sections in the door and front end panels is also under investigation.